XVII. *On the Structure and Development of the Skull in the Crocodilia.*

By W. K. Parker, *F.R.S.*, *F.Z.S.*

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[Plates LXII. to LXXI.]

Introduction.

Several years ago I received from my friend Mr. David Bartlett several ripe young embryos of a Crocodile, the species of which was undetermined. Other ripe embryos of *Crocodilus acutus* (from St. Domingo) were about the same time given to me by another friend, Mr. Henry Power, F.R.C.S.

For about twelve years no further addition was made to my collection, nor further observations recorded than such as were done, partially, soon after receiving these treasures.

But early in the summer of 1879 I received from my talented young friend, Mr. Henry F. Osborn, of Princeton, U. S., a box of the eggs of *Alligator mississipensis.* These had been laid quite recently, and contained nothing sufficiently advanced for my purpose; but soon afterwards, when this failure had been made known to Mr. Osborn, I received another box of eggs. These reached me on August the 8th; they were twenty-six in number, and all but one of them yielded me embryos.

These have served me for my earlier and most important stages; but the largest embryos were scarcely half ripe.

Shortly afterwards I received a large number (several dozen) of embryos of *Crocodilus palustris*[1], from Dr. Kynsey, P. M. O. of the Hospital, Colombo, Ceylon, who took great pains for me, employing his native assistant, Mr. S. Waytialingam, to collect them. This zealous service I owe to the influence of Sir Joseph Fayrer. An account of the nest-rifling of these "fearful wildfowl" has already appeared in the 'Proceedings' of this Society (1880, pp. 186, 187). There were about eighty of these embryos, ranging from $1\frac{5}{6}$ to 10 inches in length; they were most carefully preserved and tabulated.

I have no *dates* in the case of the embryos of the Alligator, and I can therefore only give *measurements*; but in the Crocodile embryos the time is given in each case, and this in specimens taken from two places, namely, Vadunakaloo and Talavaikal; the eggs from both these sources were evidently laid about the same time. Mr. Waytialingam says that they are laid as early as June; and as the smallest specimen measured nearly 2 inches in total length, and was taken on the 16th of July, it is probable that both the nests were filled by the middle of June. They were ripe on the 8th of September,

[1] See Günther's 'Reptiles of British India,' p. 61, pl. 8. fig. *a*. I must here call the reader's attention to the extreme beauty of the plates (by G. H. Ford) both in that work and in Dr. Gray's paper referred to on the next page.

so that *three months* may be given as the full time required for the development of the embryo, which is probably one third longer than is required in the case of the Brush-Turkey (*Talegalla*).

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The skulls of other reptiles worked out by me (the Snake, Phil. Trans. 1878, part 2; the Lizard, Phil. Trans. 1879, part 2; and the Green Turtle, 'Challenger' Reports, Zoology, vol. i. part 5) are not of themselves sufficient for comparison with that of the Crocodile; that of the Bird and of the Mammal are quite necessary before its meaning and uses can be understood.

Moreover, as the Sauropsida are built upon the foundation of the Amphibia and Fishes (Ichthyopsida) it is before all things necessary that the skull in one or the other of those *Branchiate* types be taken as a measure or pattern with which to compare that of this highly specialized *Abranchiate* form.

For now, in the ascent of the types, the more or less ossified chondrocranium is almost buried under the well-compacted framework of superficial bones, and the once capacious respiratory pharynx is reduced to a funnel-shaped vestibule of the digestive

[1] In this list I make no pretension to *completeness*. The works and papers are just such as served me in my special research.

Since this paper was read, an important memoir has appeared on the anatomy of the Crocodile, viz. " Recherches sur l'oreille moyenne des Crocodiliens et ses communications multiples avec le pharynx," by Edouard van Beneden (Archives de Biologie, vol. iii. plates 20–22, pp. 487–560 : 1882).

tube. The only permanent "cleft," the first of the series, scarcely opens externally, and serves merely as the rudiment of the tympanic labyrinth of the adult; it never takes on any respiratory function.

Thus the cranium, proper, and the visceral arches are greatly modified from what we see in such a good *fundamental type* as the Skate, the cranium being "cribbed, and cabin'd, and confined" within the fast-growing masses of the outer bones, whilst the arches are arrested early, and then wrought into fitness for new *physiological* uses.

Yet masked and curtailed as the elements of the skull are in so high a vertebrate type, they are not too modified nor too fragmentary for interpretation; the parts can, besides their relative and functional names, have a terminology given them that shall perfectly correspond with that which has been given to those of the *pure chondro-cranium* of the "Elasmobranchs," with its complex lattice-work of branchial arches.

Thus, in the present paper, whilst I shall try to name every part by its own proper morphological designation, I shall not disturb the old *anthropotomical* terms with which the anatomist is familiar.

I need scarcely say that all that is purely *morphological* in the present paper is based on *embryological* facts; and that whilst I would wish to make clear to the student fresh from his human anatomy the structure and fitness of a skull so different from that of Man, yet, on the other hand, the whole work of interpretation must be done so as to commend itself to the mind of the embryologist.

As the Crocodile is known to be one of the most ancient types inhabiting this terraqueous globe, his development is full of interest in relation to those countless Reptilian forms that have succumbed to secular changes of the earth, and have "left neither son nor nephew" in the regions where they once were dominant.

In the great structural conformity of the skull, in its early stages largely, and to a wonderful degree also permanently, to that of the Bird, there is much both to admire and to stimulate inquiry. The copious development of air-cells in the *tympanic labyrinth* is extremely like what we see in a Hornbill or a Toucan; but the "final purpose" of such a conformity is a dark riddle. On the other hand, fresh from the study of the development of *Lepidosteus*, I find no difficulty in imagining a "Ganoid" descent for the Crocodile. "I do read some tokens" of the gigantic forms of that older group "in the large composition of this" Reptile.

The skeleton of the head is composed of all the three embryonic layers—*epiblast*, *mesoblast*, and *hypoblast*—only in its hinder half; the front part, from the pituitary body forwards, is devoid of the lower layer.

Therefore, in any comparison of the head with the trunk, this must be borne in mind; the notochord only reaches to the "infundibulum," which receives the pituitary *graft*, and the hypoblastic lining of the throat ceases inside the mandibular arch; thence, above and below, the whole structure is composed merely of the upper and middle layers.

Thus in the axial and neural regions we have a *para*chordal tract with a *pro*-chordal tract in front of it; whilst, below, we have the postoral (visceral) arches, the foremost of which, the mandibular, is finished in front by *super*- (or *pre*-) oral outgrowths. Moreover, the *visceral* arches must not be confounded with the *costal* arches; these latter are found in the *outer* layer of the body-wall, the "somatopleure," whilst the visceral arches are developed in the *inner* layer, or "splanchnopleure." The fact that these two layers are only separate for a short time in the pharyngeal region, does not alter their real nature; the difference between the two sets of arches is fundamental, and only in the lower types (Ichthyopsida) do arches arise in the superficial layer of the pharynx.

1st Stage. *Embryos of* Alligator mississipensis, *Daudin*, 11 *lines long* (*head* 3, *body* 5, *tail* 3).

My smallest Crocodilian embryo, measured along its coils, was less than an inch in length, and served well for comparison with the early embryos of the other Reptilian forms already figured and described. The mesocephalic flexure was perfect, the visceral clefts visible, more than fifty somatomes were developed, and the limbs were in the condition of trowel-shaped paddles (Pl. LXII. fig. 1). The ventral laminæ were imperfect, so that the heart (*h*) protruded below the throat, and the umbilical vessels (*u. v*) came from an open abdomen. The divisions of the brain were clearly seen from the outside; the hind brain (C^3) was large and long, the mid brain (C^2) large and protuberant and ending the axial line, and the *fore* brain had already given off the rudiments of the hemispheres (C^1, C^{1a}).

The nasal sacs, eyeballs, and auditory capsules (*ol*, *e*, *au*) were already formed, and the involution of the latter (*aq.v*) was visible. There were four pairs of visceral folds behind the mouth, the mandibular, hyoid, and first and second branchial (*mn*, *hy*, $br^{1,2}$); these were separated by three clefts (cl^{1-3}), the first of which was short, crescentic, and obscure, and the other two large and open. Already the first and second visceral folds had gained largely on the other two, being thick and solid, whilst the two branchial folds were very slender and small, ready to lose their distinctness in the folds of the neck.

Seen from below (Pl. LXII. fig. 2), the mouth (*m*) is bordered behind by the solid mandibular folds (*mn*); behind these are the hyoid folds (*hy*), which have an opercular fold, as in fishes. There is a wide open space between them and the first branchial fold, and then a smaller cleft, right and left, between the first and second branchials ($br^{1,2}$). The open oral space (*m*) has, right and left of it, a solid semioval fold, the maxillo-palatine (*mx.p*), then there is a clear chink on each side, and, in front, a fan-shaped lobe, cleft in the middle, and, flanking each lobe, the right and left olfactory sacs (*ol*); this double middle fold is the "fronto-nasal process" (*f.n.p*).

When the inferior (postoral) arches are removed, and the head viewed from below (Pl. LXIII. fig. 1) the form of the folds that finish the face in front is better seen.

These parts—the fronto-nasal and maxillo-palatine folds (*f.n.p*, *mx.p*)—are in front of the hypoblastic layer of the embryo, and therefore have to be considered, *in the present state of our knowledge*, merely as additions or outgrowths to the true visceral folds, which are lined with the *lower* embryonic layer.

In the preparation figured, the myelon (*my*) has been cut through, and also the notochord (*nc*) and investing mass (*iv*); also the mandibular folds and hyoid arches (*mn*, *hy*); these arches are now becoming cartilaginous. The notochord can be seen shining through the hinder part of the floor of the head; in front of it there is an opening partly filled by a sort of glandular structure—the rudimentary pituitary body (fig. 2, *py*). From the middle of the mandibular fold, right and left, a membranous fold appears with a free sinuously emarginate hinder edge, this fold, which runs up to the fronto-nasal fold, is the *epiblastic* lining of the palate; the higher stratum of mucous membrane behind it is composed of hypoblast, which reaches in front to the notch in which the pituitary body lies, and on each side passes into the first cleft (cl^1). In front of the first cleft the hypoblast unites with epiblast, ending there. The second cleft (cl^2) is seen behind the hyoid fold (*hy*); the other folds and clefts were not figured: these parts had been cut away.

Inside, the solid maxillo-palatine folds (*mx.p*), right and left, are thick and bulbous; these swellings are the rudiments of the lower or *hard* palate, which is so greatly developed afterwards. When the mucous membrane and palatal skin had been removed (Pl. LXIII. fig. 2), then the rudimentary chondrocranium was displayed; the mandibular arches only (*mn*) were left in section in this preparation. The notochord (*nc*) seems to be a straight, horizontally placed rod, but its position is really oblique (see 2nd stage, Pl. LXIII. fig. 7, *nc*). It lessens gradually to its fore end, where it is somewhat bulbous, and shows but little tendency to become moniliform. On each side of the notochord the parachordal cartilage (investing mass, *iv*) is becoming solid; it is almost regular in width, but is indented by the corresponding auditory capsule (*au*), itself now just becoming hyaline.

The front margin of the basal plate is emarginate, bounding, as it does, the pituitary body behind; from each moiety a small horn of less consistent tissue is seen to grow forwards with an outward curve; this bovicorn structure is the prochordal part of the basis cranii, in rudiment; the horns are the "trabeculæ cranii." Here the structure is quite like what is seen in the Axolotl (Phil. Trans. 1877, pl. 22. fig. 1), except that in that type the "horns" solidify first; this is also the case in the larval Lamprey. At this stage the trabeculæ are very slight additions to the proper axial skeleton; they just help to support the first vesicle of the brain.

2nd Stage. *Embryos of* Alligator mississipensis, $1\frac{1}{2}$ *inch long* (*head* 4 *lines, body* 6, *tail* 8).

At this stage the embryo has not only taken on the pentadactyle character, it is also evidently a reptile, and nearly half its length is due to the growth of the coiled tail. The number of somatomes has greatly increased, and the lobes of the face are now confluent; yet the mesocephalic flexure is still perfect, throwing the huge mid brain (Pl. LXII. fig. 3, C^2) forwards, as though it were the end of the embryo. The hemispheres (C^{1a}) are very much elongated in front of the pineal region (*pl*); the hind brain (C^3) is still very long and thinly covered.

The prenasal beak is now definitely formed, and projects considerably beyond the brain, so that the outer nostrils (*ol*, *e.n*) are carried away from the eyeballs; these latter are immense, and are fitted with well-margined sockets.

The auditory capsules (*au*) are still evident as ovoidal swellings on the outside, and the involution (*aq.v*) is evident as a lipped slit; a curtain hangs down over the closed first cleft.

The mouth (figs. 3, 4, *m*) is now well formed and has large angles; the mandibles (*mn*) are still short as compared with the upper or maxillo-palatine margin of the mouth; the hyoid (*hy*) lies some distance behind the mandibles, and the clefts are nearly closed. When the inferior arches are removed, and the head is viewed from below (Pl. LXIII. fig. 3), we see how much the palatine region has developed in front of the pituitary involution[1] (*py*).

At the mid line, where the faucial and palatine territories meet, there is a sagittiform recess, in the centre of which the pituitary rudiment is to be found.

The hinder tract is short, and passes right and left into the clefts, the first of which (cl^1) only is figured; it lies within and behind the mandible (*mn*). The epiblastic mucous membrane in front of this pair of clefts is now greatly elongated, narrows towards the front, and then widens again somewhat. In each angle, in front, the lacrymal "involutions" (*l.i*) are seen. Right and left, the club-shaped maxillo-palatine folds (*mx.p*) are growing inwards, especially in front, and these inner lobes contain the rudiments of the *hard palate*. The upper palatine skin shows a median seam when the two sides have grown together. The nasal sacs and their openings (*ol*, *e.n*) are still quite inferior in position, and the lobes of the fronto-nasal process (*f.n.p*) are growing small; they now form the anterior margin of the palate, where the promaxillary teeth will be.

When the palatal and faucial skin has been removed, then the hardening basis cranii is exposed (Pl. LXIII. fig. 4); in relation to the early chondrocranium of the Vertebrata, generally, this is a very important dissection.

At present the notochord (*nc*) is half as long as the whole basal tract; it was two

[1] In my earlier papers I have been in the habit of calling certain passages about and in front of the mouth, as well as the mouth itself, by the term "clefts." Now, and for the future, I shall only call those passages *clefts* that lie behind the mouth, and in which the epiblast unites with the hypoblast. In the mouth, pituitary rudiment, lachrymal, and nasal passages, the whole tract, outside and in, is merely epiblast; these will be called "involutions."

thirds the length in the first stage (fig. 2), and it will be relatively much shorter than now. Although it appears to be straight in this aspect, it is really bent forwards near the end, and hooked downwards at the end (figs. 7, 8, *nc*), where it is slightly bulbous. This is like what I found in the same stage in *Chelone viridis* (*op. cit.* pl. 2. fig. 4).

The parachordal cartilage grows up into the recess under the mid brain (C^2) much further than the notochord, so that, already, that rod has retreated from its first position between the moieties of the investing mesoblast; the ascending plate of cartilage is the "posterior clinoid wall" (*p.cl.*), a part which is developed much more in the Sauropsida than in the Ichthyopsida.

The folding over of the notochord at its end is the counterpart, in the skeleton, of the folding over of the mid brain; both the fore skull and the fore brain appear to be *outgrowths* from the proper end of the skeletal and neural axes; the arrest of the hypoblast at this point favours such a view; this view would also put the optic and olfactory nerves out of the normal category[1].

The parachordal plate, which is still distinct from the auditory capsules, has very sinuous outlines, for it is pinched in by the pressure of those capsules and by the cranial nerves.

Behind (Pl. LXIII. figs. 4, 6, *oc.c*, *iv*) the occipital condyles are being formed, and the plate of cartilage in front of them is pierced by the hypoglossal nerves (XII), and notched by the glosso-pharyngeal and vagus nerves (IX, X).

Also the growth of the cochleæ (*chl*) towards the mid line causes the parachordals to become very narrow, thence they widen out and get in front of the auditory capsules (*au*), and at this, their widest part, they are notched by the large Gasserian ganglia (V).

As seen from below (fig. 4, *iv*) these plates seem to end in the postpituitary region, on this lower plane; but the upper view (fig. 6) and the sections (figs. 7, 8) correct this view.

The two plates ascend under the hind brain (C^3) into the large space within the folded mid brain (C^2), and grow, right and left, into large wings; these wings are the alisphenoids (*al.s*); they grow from the "posterior clinoid wall" (*p. cl*). The base of each wing grows round the fore edge of the hind skull, and the tip of each touches the hind corner of the adze-shaped orbito-sphenoid (*o.s*); the upper surface of these wings is sinuous, and fits to the swellings of the overlying membrano-cranium.

The basal plate looks outward, right and left, at the fore end, and is notched (for the notochord, *nc*) in the middle. Between these points the trabeculæ (*tr*) arise; they are very thick, short, pointed "horns," curving towards each other, but kept apart in front by the thick intertrabecular bar (figs. 4–6, *i.tr*). Above (fig. 6) the trabeculæ lie on

[1] The reader will observe, if he compares this with former papers of mine, that my views are becoming more and more in harmony with those of Prof. Huxley and Mr. Balfour. The truth of the matter is this, that I am gradually placing my work on an accurate embryological basis.

the same plane as the investing mass from which they arise; but below (figs. 4 & 5) they project, being thick, oval in section, or compressed.

Behind and below they would seem to be *articulated* to the moieties of the "investing mass;" but they are really continuous, and do not form so distinct a joint as in *Chelone* ("Turtle's Skull," *op. cit.* pl. 2. figs. 6, 7). This apparent distinctness of the trabeculæ as seen from above and below is partly due to the fact that the internal carotid artery (*i.c*) is entering the skull at that part.

Yet these inferior projections may be taken as the apices of the trabeculæ, and these projections backwards into a cartilaginous "lingula" (see "Fowl's Skull," Phil. Trans. 1869, pls. 81, 82, *lg*) is for the purpose of forming a root, from which may grow the copious periosteal laminæ that form each "anterior tympanic recess."

The fore half of the chondrocranium is not finished by the trabeculæ. I have just spoken of an intertrabecular bar (*i.tr*); this large and important element is nearly as distinct in the Crocodile as in the Green Turtle (*op. cit.* pl. 2. figs. 6, 7, *i. tr*, *pn*). This agyzous prepituitary element helps the winged trabeculæ to finish the foundations of the skull in front; it is a solid subfalcate plate or bar, with its convex margin above, and its concave outline below. The lower edge is thick, but subcultrate behind, where it is jammed in between the trabeculæ; it projects a little into the pituitary space (*py*). In front (figs. 4 & 5, *i.tr*) this bar has become lessened, and it curves downwards behind the frontal wall of the head, as the prenasal rostrum (*pn*; see also "Fowl's Skull," pl. 81). The trabeculæ do not end at the part where they embrace the intertrabecula, but run along its upper part as thin laminæ, and then break out, right and left, as the large adze-shaped orbito-sphenoids (Pl. LXIII. figs. 5, 6, and Pl. LXIV. figs. 1, 2, *tr*, *i.tr*, *o.s*).

These "anterior sphenoidal wings" form nearly half of the lateral part of the skull; they touch the small "posterior wings" (*al.s*) by their more extended hinder wing-tip, and by the lesser front tips they grow up to the nasal sacs (*ol*), walling in the "rhinencephalon" (fig. 6, C^{1b}) on the outside. These elegant wings are convex above, near the middle, but become sinuous externally, their margin is convex above, before and behind it forms a concave line.

The large optic nerves (II) escape behind the orbito-sphenoids, close to the part where the trabeculæ flatten themselves against the intertrabecular wall.

The pituitary body (*py*) is still a racemose mass, behind which we see the hooked notochord (*nc*), the emarginate ascending wall of the investing mass (*p.cl*), and behind this the basilar artery (*b. a*).

The nasal capsules (Pl. LXIII. figs. 3, 4, and Pl. LXIV. fig. 1, *ol*) are scarcely cartilaginous as yet; but the auditory sacs have a more solid wall (Pl. LXIII. figs. 4, 6, 8, Pl. LXIV. fig. 4, and Pl. LXVIII. fig. 3, *au*); this is still distinct from the investing mass (*iv*). Each capsule is now of a pyriform shape, broad in front, narrower behind, and lobate on the inner face, whence the membranous labyrinth is giving off the rudimentary cochlea (*chl*). The horizontal and posterior canals can be seen from below, shining through the walls (Pl. LXIII. fig. 4, *h.s.c. p.s.c*), and the anterior canal can be seen, partly, in the sectional view from the inside (fig. 8, *a.s.c*) in front of the "meatus internus" (VIII).

In this stage we can thus trace the original elements of the chondrocranium; they are—(*a*) the basal plate (*para*chordals) and notochord, (*b*) the three *pro*chordal bars, and (*c*) the olfactory and auditory sense-capsules; the eyeballs are not counted, because of their freedom from the rest of the skull, yet they affect its form very much by their bulk and shape.

The skull is finished above by a huge membranous roof (fontanelle), for even in the occipital region there is, at present, no solid cartilage above.

The ventral walls of the head are very contracted (Pl. LXII. figs. 3, 4), and only the first and second visceral arches are well developed, for the third has merely distal rudiments.

The first arch or mandibular (Pl. LXIII. figs. 3, 4, Pl. LXIV. figs. 1–4, and Pl. LXVIII. figs. 1 & 9, *q*, *mk*, *ar*) is composed of an *epi-* and a *ceratobranchial* element; but these parts are very large.

The first cleft (cl^1), seen in these dissections and sections, runs (already) in two directions, namely, obliquely inwards and outwards; inwards to form the rudiment of the complex system of Eustachian passages, and outwards to form the cavity of the drum—"cavum tympani."

At present the Eustachian opening is a mere lipped crescentic slit, with its concave border looking towards the postero-internal surface of the mandible (*mn*); its position in the throat is shown in the vertical section (Pl. LXIII. figs. 7, 8, cl^1); and its actual form and extent in the subhorizontal sections (Pl. LXIV. fig. 4, and Pl. LXVIII. figs. 1–3, cl^1).

Below the mouth, in some of these sections (Pl. LXIV. figs. 1, 2, and Pl. LXVIII. figs. 7, 8, *mk*), the free mandible is seen to be a solid, somewhat flattened, rod in all its fore part; but behind (Pl. LXVIII. figs. 5, 6, 9, *ar*) it is considerably dilated to form the articular head and the angular process. On that process the main part of the next arch, the "ceratohyal" (*c.hy*), rests, and not only rests, but is already fused with it, so that at this point the two arches are continuous. Below this conjunction (Pl. LXVIII. figs. 6 & 9, *ar*, *c.hy*) the angular process is seen to be short, and reflected downwards.

The quadrate cartilage, or mandibular pier (Pl. LXVIII. fig. 9, *q*), is very large, and its main part is crescentic, hooking in a falcate manner over the first cleft and the hyoid arch, along the fore part of the auditory capsule.

The hinder, concave, bevelled edge is already forming the front boundary of the tympanic cavity; its lower end is the solid rounded condyle for the lower jaw (*ar*, *mk*); but its front margin is developed into a thin and somewhat bilobate process, this is the "orbital process" so familiar to us in Chelonians and Birds; it is the common rudiment of the "pedicle," "ascending process," and "pterygoid cartilage;" the falcate postero-superior part of the quadrate is the "otic process" (*ot.p*).

I find no rudiments of the "ethmo-palatine," such as are seen in other Sauropsida; they are probably, when present, merely detachments of the "pterygo-quadrate," and not rudiments of a preoral arch.

The hyoid arch (Pl. LXVIII. fig. 9) is scarcely one fourth the size of the mandibular; it is also much more segmented, and corresponds very closely in its divisions with a branchial arch.

A side view (Pl. LXVIII. fig. 9) shows that there are four pairs of segments besides the basal rudiment, and of these, one, the "suprastapedial," is a special *hyoid* element not found in normal branchial arches; moreover, the distal piece of such an arch, the "hypohyal," is not distinct in the Crocodilia from the common basihyo-branchial plate. The uppermost segment or columella (*co.* = part of "pharyngo-hyal") is like a drum-stick; its height is about three times as great as its thickness; it is narrow in the middle, and dilated at each end. The next is a short oval nucleus, the "suprastapedial" (*s.st*); this is a special Crocodilian segment. The third, or "epihyal" (*e.hy*), unites the pharyngo-hyal with the main piece; above, this small curved rod is attached by ligament to the uppermost piece[1].

The main bar, or "ceratohyal" (*c.hy*), is like a rib, with its "capitulum" and "tuberculum," and, like its proper homologue in the herbivorous Mammalia, carries the epihyal; it is also tied to the columella; it lessens downwards, becoming terete, and is thoroughly fused below with the mandible, close behind the articulation with the quadrate (fig. 9, *c.hy*, *q*, *ar*); it is a gently sinuous bar. The rest of this arch, at present, is merely a median hyo-branchial tract (Pl. LXVIII. fig. 7, *b.h.br*), the hyoid part of which lies in front of the "first ceratobranchials" ($c.br^1$), or paired "thyro-hyals."

These segments are to be seen in the subhorizontal sections; in one which takes the notochord and investing mass through their common plane (Pl. LXIV. fig. 4), the relation of the mandibular and hyoid arches to the tympanic cavity (first cleft) and auditory capsule is well shown. The cavity widens as it passes forwards between the quadrate (*q*) and the auditory capsule (*au*); a lesser space is seen passing behind at an acute angle from the front parts, and running behind the quadrate and the joints of the hyoid arch. A thin shaving of the columella (*co*) or pharyngo-hyal is seen running inwards so as to touch the auditory capsule; thus the top of the main part or cerato-hyal (*c.hy*) is seen, and behind it the small epihyal (*e.hy*) is cut through.

Another very similar section (Pl. LXVIII. fig. 3) is still more instructive; it is a little higher up, and the columella (*co*) is seen fitting into the side of the auditory capsule exactly as its counterpart (the hyo-mandibular) does in the Selachians. Here the "suprastapedial" (*s.st*) is cut across above the top of the ceratohyal (*c.hy*).

[1] This separate "suprastapedial" has not turned up in any other type.

Part of a section, much like this, is figured in Pl. LXVIII. fig. 2; here the columella (*co*) dents the auditory capsule (*au*), the epihyal is just missed, and the head and shoulders of the ceratohyal (*c.hy*) are cut obliquely across.

But another section from a higher plane (Pl. LXVIII. fig. 1) is the most instructive; here the columella or pharyngo-hyal fits into a hole, the fenestra ovalis, which opens into the vestibule (*vb*); on the inside that cavity is growing into its cochlear diverticulum (*chl*). Here the small curved epihyal (*e.hy*) is cut across, and also (outside and below it) the head and shoulders (obliquely) of the ceratohyal (*c.hy*). The fore part of the investing mass (*iv*), the body of the quadrate (*q*), and the first cleft (cl^1) are seen, as cut across, in this figure.

In a lower section (Pl. LXVIII. fig. 4) the quadrate cartilage is seen sending its long orbital process inwards and forwards; behind it the ceratohyal (*c.hy*) is cut across. In another figure (fig. 6) the ceratohyal (*c.hy*, *ar*) is seen as cut across at its junction with the angular part of the mandible.

In a still lower section (Pl. LXVIII. fig. 7) Meckel's cartilage (*mk*) is cut across, and behind it, at the middle of the floor of the face, we see the basihyo-branchial plate (*b.h.br*) with the rudimentary first ceratobranchials ($c.br^1$); these are gently curved, rounded rods of cartilage. In the lowest of these sections (Pl. LXVIII. fig. 8) the larynx (*lx*) is cut along; and here the curved thyrohyal or first ceratobranchial is cut in its curve so as to look like two pieces.

The very ichthyic condition of these arches seen in this stage will be found to be greatly transformed in the stages that follow.

The next stage will illustrate the further growth of the chondrocranium and visceral arches, and the first definite appearance of the investing bones.

3rd Stage. *Embryos of* Crocodilus palustris, *from* $1\frac{5}{6}$ *inch to* $2\frac{1}{3}$ *inches.*

a. *Chondrocranium.*

This stage (Pl. LXII. figs. 5–9, Pl. LXIV. figs. 5–11, and Pl. LXVIII. figs. 10, 11) follows very closely upon the last, but belongs to another species and genus.

I shall give all the details of the chondrocranium in the next stage, but in this the main things will be noticed; the cartilaginous framework is already perfectly formed.

The notochord (Pl. LXIV. figs. 5–8, *nc*) is now closely embraced by the parachordal tracts, behind, and the cartilage has formed a semilune, below, half embracing it; this is the transversely oval occipital condyle (*oc.c*). Then for three fifths of its extent the notochord is naked below, but it gains a superior position in front, the basal (parachordal) tracts having coalesced again beneath it. It escapes once more at the end, where it projects, inwards and upwards, into the neat circular pituitary space (*py*). The basal cartilage is dilated behind and in front of the auditory capsule, but is greatly pinched-in in the middle by the ingrowth of the cochlear pouches (*chl*). The large *pre-* and *post*auditory nerve-passages (V, IX, X) are very similar, and besides a pair of passages for veins, there is a small posterior hole, right and left, for the hypoglossal nerve (XII). In the fore half of the hind skull the cartilage is burrowed on its lower face by the converging internal carotoid arteries (*i.c*), which pass into the skull through the pituitary space on each side of the apex of the notochord. This space is at present filled with the gland-like racemose mass of the pituitary body (*py*); one of the "acini" is much larger than the rest, and is in the centre of the mass.

The lingular processes of the trabeculæ (*tr*) end as solid rod-like bars with bulbous and somewhat inturned ends, some distance outside the pituitary space. These rods converge, are separated by a space only equal to their own width, and then become flat and vertical, and run straight forwards. The space between them is filled by the solid rounded end of the elongating intertrabecular bar (*i.tr*); this bar is, indeed, a vertical plate, the orbito-nasal septum, and ends, in front, in the rounded (prenasal) rostrum (*p.n*); this median element grows lower down than the lateral bars.

The trabeculæ only run up to the front third of the intertrabecula; they thicken a little, become thinner again, and are then enlarged into a solid wedge-like mass; these lobes are the "cornua trabeculæ," the "super-vomerine laminæ" of my paper on the Fowl's Skull (*op. cit.* pl. 83. fig. 4, *s.v.l*). The occipital and nasal roofs (Pl. LXIV. fig. 9, *s.o, na*) are now chondrified; the former are bounded by the auditory capsules (*au*), which appear on the upper surface, right and left.

b. *Visceral Arches.*

The mandibles and their piers are rapidly increasing in size (Pl. LXIV. figs. 8, 10, 11, and Pl. LXVIII. fig. 10, *q, mk, ar*); and the hyoid arch (Pl. LXVIII. figs. 10, 11) is now complete, and bears the same relation, in size, to the mandibular arch, that the branchial arches, proper, in Ganoid and Teleostean fishes do to the hyoid and the mandibular; but this sudden arrest of the postmandibular arches is attended with new specializations of the lessened elements; and the tracts of cartilage that do appear serve every purpose of the new functions to which they are dedicated.

The quadrate (Pl. LXVIII. fig. 10, *q*) has now developed an angular projection from the fore corner of its huge otic process (*ot.p*) above; the "orbital process" also is much more developed. The condition of this process here is very instructive; it is a well-formed rudiment of both the "pterygoid cartilage" (*pg.c*) and the "pedicle"—such a pedicle as exists in *Triton* and *Salamandra*, where the articular part of the pedicle does not coalesce with the basis cranii, but is merely a facet on the inside of the "ascending process." Here the ascending process (*a.p*) is arrested as a flat triangular flap; in the ordinary Lizard it is a *distinct*, long, terete rod of cartilage ("Lizard's Skull," pl. 41. fig. 3, *e.pg*), which afterwards ossifies as the "epipterygoidean columella." In *Hatteria* (Günther, Phil. Trans. 1867, pl. 1. figs. 3, 4) it is a large flat piece; in both it has exactly the same position, and general anatomical relations, as the permanently non-segmented and unossified counterpart in the "Urodeles."

In the Turtle (Skull of *Chelone*, 'Challenger Reports,' vol. i. pt. 5, pl. 10. fig. 7) the small epipterygoid is at first a flap of cartilage hanging down from the apex of the orbital process of the quadrate, which afterwards becomes segmented and ossified; it corresponds with such a *remnant of* cartilage as is often seen on the *pterygoid bone* in adult Urodeles.

To any one familiar with the rich development of the visceral arches in Fishes, and aware that the mandibular is merely a highly modified visceral or branchial arch, these modifications will present no real difficulty. Morphologically speaking, the quadrate is an epibranchial, and the articulo-Meckelian rod a cerato-branchial element. Any separate cartilages developed between the antorbital and postorbital regions of the palate are merely to be looked upon as segments or dismemberments of the epibranchial piece—the quadrate. Above the Fishes, I know of no other segment in this arch that can with safety be called pharyngo-branchial, except the epipterygoid of the Lacertilia; I am doubtful even about that of the Chelonia, which is developed differently; but the "ethmo-palatine" and "post-palatine" rudiments so well seen in the Axolotl ("Skull of Urodeles," Phil. Trans. 1877, pl. 24. figs. 1–3) are all (*I now consider*) to be looked upon as remnants of the huge "pterygo-quadrate" of the Shark.

The lower or articular part of the quadrate of the Crocodile is now closely embraced behind by the cerato-hyal (Pl. LXVIII. fig. 10, *q.c*, *ar*, *c.hy*), and the articular head of the mandible sends backwards a large, notched, angular process.

The hyoid arch (Pl. LXVIII. figs. 10, 11) is now perfect; the uppermost piece (or pharyngo-branchial element) has now become a long "columella;" it is ouly partially distinct from the cartilaginous operculum (base of "stapes") of the auditory capsule; in this the Sauropsida differ from the Amphibia, which have the stapes and medio-stapedial separate. Yet, as I have shown in my former papers on the Reptilian skull, the ring of thin cartilage embracing the dorsal end of the uppermost hyoid segment is partially a separate tract of cartilage, whose cells are much flatter and less characteristic of that tissue. I shall soon show that a separate bony centre is formed in the stapedial end of the columella (Pl. LXIX. figs. 2, 3); these parts are special developments of the *hyoid*.

As in the branchial arches, proper, of the Sturgeon, this pharyngo-hyal piece is subdivided; the proximal segment forms the base and stem of the columella (*st*, *m.st*), and a process to which the suprastapedial (*s.st*) is attached; the distal piece is the *extrastapedial* part.

The columella is comparable both to a pruning-hook and a scythe; it has two side handles, and ends in a broad blade with a thickened convex back. The back is turned outwards and upwards (fig. 10, *e.st*), and overlies the concave bevelled postero-superior edge of the quadrate cartilage; and the sharp concave edge looks upwards and inwards.

The shaft of the columella (medio-stapedial, *m.st*) turns inwards and a little backwards, and the dilated stapedial end fits into the oblique fenestra ovalis (see Pl. LXV. figs. 3 & 8).

Over the temporary and imperfect joint of the columella, but arising most from the upper part, we see a triangular ascending process (*s.st*) on which the large reniform *suprastapedial* (*s.st*) rests, and from the lower side, in front of the segmentation, the extrastapedial gives off a small curved spur, which is hooked backwards; this is the *infrastapedial* process (*i.st*). Attached to the descending process of the extrastapedial (infrastapedial) we see a small curved segment of cartilage; this is the "epihyal" (*e.hy*), a distinct piece, a distinct centre in the Ganoid and Teleostean Fishes.

This small epihyal conjugates the distal pharyngo-hyal piece, or extrastapedial, with the main hyoid bar, the ceratohyal (*c.hy*); it is attached to its "shoulder." The main bar then descends as a considerable cartilage, but less than a fourth the bulk of the quadrate, and is fused with the mandible behind its articulation with the quadrate; this bar follows the curve of the quadrate.

We can describe the distal part of the hyoid arch in the next stage (see Pl. LXV. fig. 4), where it will be seen to be greatly developed as compared with what is seen in the *second stage* (Pl. LXVIII. fig. 7).

I shall take up the stapedio-hyoid chain again after describing the other parts of the skull in their various changes. But it will be necessary to reexamine the metamorphosis of this curiously modified *branchial arch* when I come to summarize the whole.

c. *Investing Bones.*

Before describing the investing bones I will call attention to the structure of the palate, as displayed in the lower view of the head of an embryo $2\frac{1}{3}$ inches long, the lower arches of which had been removed. In this state (Pl. LXIV. fig. 7) the membranous palate has become very extensive, but the right and left selvedges have not formed a perfect seam. The hinder third is open, and in the front part of this open space the middle (or internal) nasal opening (*i.n*) can be seen, right and left of the fold of skin that covers the base of the orbital septum.

The hinder third of the notch is notched again; here the posterior narial opening passes into a rounded narrow median space, in which the right and left tympanic clefts (cl^1) meet. These sigmoid passages can be seen to terminate externally behind the quadrate cartilage (*q*).

Here we have the rudimentary condition of the double tympano-Eustachian labyrinth of the adult Crocodile. The Eustachian openings have melted into one at the mid line as in the "Batrachia Aglossa" (see Günther's "Batrachia Salientia," 1859, p. 1, and my "Batrachian Skull," part 2, Phil. Trans. 1876, pl. 59. fig. 2). In the earlier stages (Pl. LXIII.) the Eustachian openings (cl^1) are far apart, as in the Batrachia, generally.

When the head, at this stage, is carefully peeled and stained, fine reticulations of young bone-cells can be traced (Pl. LXIV. figs. 8–11); these lie along the appointed lines, and can be named accordingly.

The brim of the cranial basin is pyriform, the narrow end being in front (Pl. LXIV. fig. 9); narrow, reticulated strips of young bone now lie along the rim and also further outwards.

The parietals are half the length of the frontals (*f, p*); the latter are sigmoid and the former crescentic. Outside the parietals we see the postorbitals and the squamosals (*pt.o, sq*), and in front of the eyeballs the small arcuate prefrontals (*p.f*). Over the nasals sacs (*na*) the small nasals (*n*) lie; they are pyriform, with a sharp end in front; outside these are the oblong maxillaries (*mx*), and margining the fore face the premaxillaries (*px*).

The two latter pairs of bones are also well seen from below (fig. 8); within the boundary formed by these we see a pair of fine curved styles that lie behind the middle or inner nares (*i.n*); these are the vomers (*v*), their convex outline is inwards.

So also is that of the much larger palatine bones (*pa*), whose thick fore end is turned outwards towards the maxillaries; the transpalatines (*t.pa*) and the pterygoids (*pg*) bound the hinder margin, externally and within, of the subocular palatine fenestra. The transpalatines are angular and apiculate; the pterygoids are thick in their inner part, and falcate. Outside the sharp fore end of the transpalatine, lies the sharp jugal style (*j*), and overlapping it the smaller quadrate jugal (*q.j*). Bony traces resting on the maxillary below and in front of the eyeball form the rudiment of the lacrymal, and *five* tracts of young bony tissue are appearing on each free mandible (figs. 10, 11, *d, sp, cr, s.ag, ag*); the two first of these, the dentary and splenial, are the longest; the coronoid, supraangular, and angular are shorter, and invest the high hind part of the bar.

I have not succeeded in finding any more investing bones than these, in the more advanced stages, except the "basitemporals," and I have not found any *endocranial centre* at this date; therefore the investing bones appear first, and are almost exactly synchronous. These bony tracts would weigh, together, scarcely more than a grain; they are sufficient, however, to form the seed-plots, as it were, of the "osteoblasts" that are needed to develop the heavy bony vegetations that become the outwork of the skull of the adult Crocodile.

4th Stage. *Embryos of* Crocodilus palustris, $3\frac{1}{2}$ *inches long.*

a. *Chondrocranium.*

In this stage I am able to show the perfected chondrocranium before ossification sets in and the visceral arches with that process just begun.

The hind skull is now only half as long as the *prochordal* part; this is mainly due to the rapid elongation of the intertrabecula and the nasal capsules (Pl. LXV. figs. 1–4).

The single occipital condyle (*oc.c*) is an elegant crescent, embracing the notochord (*nc*); much of that rod is naked behind on the lower surface, but is invested in front, and is only seen again at its apex in the back of the round pituitary space (*py*). The whole of the hinder chondrocranial walls are very distinct from the larger lobulated auditory capsules (*au*). Here the hypoglossal nerve (XII) passes through the "posterior condyloid foramen" (Miall)[1].

The cochlear diverticula of the auditory capsules (*chl*) have coalesced with the basal plate (*iv*); but laterally, and above, the occipital arch is quite distinct from them, and where the ninth and tenth nerves (IX, X) emerge there is a large oval open space. Above, the supraoccipital cartilage roofs in three fourths of the hind skull, forms a flange on each side to the back of the auditory capsules, has concave lateral edges and then spreads out again, but to a lesser degree, in front of the capsules. The ascending fore end of the double basal plate is now a continuous slanting wall of cartilage leaning over the pituitary space behind (fig. 1, *p.cl*, *py*). From this wall a flying buttress is thrown across, right and left, and this buttress passes into the thickened coping of the alisphenoidal wall (*al.s*). That thickening is developed behind into a crescentic horn, which embraces the front outer corner of the auditory capsule; this process is very thick and strong below (fig. 2), and the two hold, like opened tongs, the swollen front lobes which have the anterior ampullæ (*a.s.c*) inside. The thick top of the alisphenoidal wall (*al.s*) runs beyond that limited part, and curving round, passes into the hind corner of the orbitosphenoid (*o.s*); thus there is below a large "orbito-alisphenoidal fenestra" (*o.al.f*). Below each flying buttress, sent out from the postclinoid wall, there is a large recess; it has the auditory capsule above and outside it, and the basal plate (*iv*) bounding it below and towards the middle; this is the huge primary "foramen ovale" (V) for the trigeminal nerve and Gasserian ganglion. In front and below, the alisphenoid (*al.s*) grows downwards, margining the pituitary cup above, and by a thick inturned process uniting with that cup as a partial rim. There is, then, inferolaterally, a lesser crescentic fenestra, the "lower or alisphenoidal fenestra" (*al.f*); this transmits the lesser preauditory cranial nerves. The rest of the alisphenoid is a narrow convex band, which runs forwards and inwards, and is confluent with the posteroinferior angle of the orbitosphenoid (*o.s*); where these two bands converge to join the orbitosphenoids, there, on the upper surface, we see the foramina for the optic nerves (fig. 1, II); these are separated by the sharp top of the intertrabecular bar (*i.tr*).

The long rod-like structure which forms the base of the prepituitary region of the skull encloses the front and sides of the circular pituitary space, below, by its forks; these short forks are mamillated at their end, and project from the general surface of the cartilage. They converge rapidly to embrace the intertrabecular bar, which is

[1] In my former papers on the skulls of the Sauropsida, led by the analogy of the Mammalia, I have considered the *anterior* condyloid foramen as the passage for the hypoglossal nerve. I suppose that dissection would show that I have been in error.

now more than twice as long as the parachordal tract. The whole base gradually lessens forwards, but at its middle, in the ethmoidal region, the lateral elements (trabeculæ, *tr*) cease. The intertrabecula then enlarges somewhat, gradually lessens again, and ends in front of its own crest, the septum nasi, in a spearpoint-like process, the prenasal rostrum (*p.n*), which turns a little downwards, and projects slightly beyond the nasal labyrinth.

The flattened trabeculæ, after giving off the orbito-sphenoids (*o.s*), swell into a short solid wedge; the two wedges fill in the space between the hind lobes of the nasal capsule below: they are the cornua trabeculæ (*c.tr*). These cornua in short-faced forms, such as the Amphibia, spread into the fore face; here, in the race of growth, they are left midway by the fast-growing intertrabecular bar.

The trabeculæ almost touch each other above, where they give off the orbito-sphenoidal wings (fig. 1, *o.s*); these together form a lozenge-shaped *hammock* for the fore brain to lie on, and, whilst ending in a sharp point on each side in front, are tied by strong cartilaginous tapes to the posterior wings, or alisphenoids (*al.s*).

The large pyriform anterior fenestræ, and the small oblong fenestræ behind them, bring this skull very near that of the Lizard ("Skull of Lacertilia," Phil. Trans. 1879, pl. 43). The ethmo-nasal crest of the middle bar (*p.e*) is exposed in its hinder part, in front of and between the orbito-sphenoids; it there forms a sort of "crista galli" between the olfactory lobes, that rest upon a concave part of the roof of the nasal capsules. This hinder, more swollen part of these capsules corresponds to the ethmoidal region in the Mammal, but is very simple within. After a sudden contraction the nasal roof and walls are enlarged again, sinuously, but, on the whole, are gently lessened up to their fore end. The olfactory nerves pass through a single hole on each side behind the higher part of the roof in the front of the rhinencephalic recess. The walls in the true nasal, as well as in the ethmoidal, region, pass across, below, and form a very complete floor, becoming confluent (as I shall show in the next stages) with the intertrabeculæ for some extent.

In front, they are bulbous below, and the semi-distinct alæ nasi (*al.n*) form two upper bulbs twice as large as those below; these latter are perforated in their middle (above). This crescentic passage, with its horns looking backwards, is the external nostril (*e.n*). Here the connate, circular, valvular fold is so specialized as to open on the *upper* surface of the head, whereas the primary position of the opening is below.

The auditory capsules (*au*) are only confluent with the rest of the chondrocranium below; they are very large, and have lost much of their original ovoidal shape. The semicircular canals (*a.s.c*, *h.s.c*, *p.s.c*) are large and shine through the unossified cartilage; so also do the other processes of the membranous labyrinth. A large pyriform tract of each capsule is seen on the upper surface of the skull; its narrow end is in front, and that part projects outwards, and is produced into an angle.

Below (Pl. LXV. figs. 2, 3), the sigmoid cochlear rudiments (*chl*) grow towards the notochord; seen obliquely (fig. 3), there are two fenestræ, both oval in shape; that which is on the inside opens into the cochlea ("fenestra rotunda," *f.r*), and that which is on the outside opens into the vestibule (*f. ovalis*, *fs.o*); the narrow tract of cartilage between these passages is afterwards ossified by the "opisthotic bone."

Before the anterior semicircular canal opens into the posterior it enlarges (fig. 3, *a.s.c*, *p.s.c*), so as to have the appearance of one large arch with an "ampulla" at each end.

b. *Visceral Arches.*

The inferior arches (Pl. LXV. fig. 4, *July* 24th, and Pl. LXVIII. figs. 12, 13, 14, *July* 20th) are now well developed, and bony shafts are forming in some of the rods on each side. The anterior angular process of the quadrate (Pl. LXV. fig. 4, *q*) is still larger, and so is the orbital process, which is now at its fullest development—*in this type*; it shows a rudimentary ascending process and pterygoid cartilage (*a.p*, *pg.c*). The main body of the quadrate is now elegantly scooped, from the solid part to the hind border, so as to form a crescentic hollow, enlarging the tympanic space. The rounded lower part above the condyle is enringed with an ectosteal tract, the quadrate bone; the condyle is hemispherical at present. The joint was dislocated in the specimen figured, and the columella appears too low down; the other figures (Pl. LXVIII. figs. 12, 13) of a younger embryo correct this. The saddle-shaped facet on the lower jaw is well formed, and there is a considerable angular process. The Meckelian rod (*mk*) gradually lessens to half the thickness it has, proximally, and then turns outwards, and is somewhat flattened at the end; it is long and gently arcuate. Between the right and left rods, in front, there is a wedge of cartilage interposed, the most distinct basal piece ("basimandibular") I have yet seen[1], except in the Green Turtle (see Turtle's Skull, *op. cit.* pl. 3. fig. 6).

Noting a long facet of cartilage on the outside of the descending plate of the pterygoid bone (Pl. LXV. fig. 8, *pg.c'*), I suspected that it would have its counterpart in the mandible: it has (see Pl. LXV. fig. 4, *cr.c*). This is the rudimentary "coronoid cartilage," a large structure in the *Lepidosteus* and in *Amia calva*, but in them it forms part of the mandibular rod. The "pterygoid cartilage" (*pg.c'*) or facet on the descending plate of the pterygoid bone is another equally instructive segment; besides this separate piece the lower horizontal fork of the quadrate (*pg.c*) shows a continuous *remnant* of the large forth-growing pterygoid process of the *Urodeles* and the *Selachians*. The oval patch attached to the inner face of the coronoid bone (see Pl. LXVI. fig. 2, *cr*, *cr.c*) plays upon the patch above. The *stapedio-hyoid* chain is shown *in situ* in Pl. LXV. fig. 4; it is figured from a somewhat younger embryo, and detached (Pl. LXVIII. figs. 12, 13, 14); in that dissection I was able to make out a true

[1] My friend Mr. Charles Stewart long ago pointed out to me this conjugation and dilatation of the distal ends of the mandible in the embryo Crocodile.

"cartilaginous annulus tympanicus" (*a.ty*), with long cells, however, like those of the stapedial base of the columella. This is quite like that found in *Chelone viridis* ("Turtle's Skull," *op. cit.* pl. 10. figs. 10, *a.ty*).

The main part of the hyoid arch, the ceratohyal (*c.hy*), is still perfectly continuous with the mandible, and immediately in front of its confluence, on the outside, a diverticulum of the tympanic cavity is growing downwards into the substance of the articular cartilage; this is the "siphonium" (*sph*), forming, already, the large air-cell of the lower jaw. There is still a joint between the ceratohyal and epihyal (*e.hy*), below; and between that small, curved, normal segment and the extrastapedial (*e.st*), above. That part of the columella is still distinct from the mediostapedial (*m.st*), which, contrary to rule, gives off the suprastapedial stem. This latter process ($s.st^1$) is a flat triangular blade, with its broad end outwards, and is, now, confluent with the suprastapedial segment (*s.st*); the seam is still visible. The suprastapedial is a bilobate thick flap, notched above, and its outer edge ribbed. The extrastapedial (*e.st*) is a large falcate plate with a thickly ribbed edge above. The mediostapedial and this thick edge is turned almost directly outward, so as to make this part seem like a mere rod. But this is only the back of the upper part, for the plate grows inwards and backwards, and ends below and behind in a notched angle; to this posterior notch the epihyal is articulated; the long, convex, postero-internal part of the extrastapedial has a neatly thickened selvedge; the top of the extrastapedial is somewhat dilated.

At present the mediostapedial shaft, only, is ossified, *not the base*; the bony tract stops, distally, where the suprastapedial is given off: this bone corresponds to the "hyomandibular" of a Teleostean or a Ganoid fish; the unossified proximal end is always a separate cartilage (*stapes*) in the Amphibia; it is never differentiated in Fishes so as to fit into a "fenestra," although the hyomandibular pushes far into the side of the auditory capsule in the Sharks (see Gegenbaur, plates 11 and 12).

5th Stage. *Embryos of* Alligator mississipensis, $4\frac{1}{2}$ *inches long, and of* Crocodilus palustris, $4\frac{1}{2}$ *and* 5 *inches long.*

a. *Endocranium.*

Again, before describing the endocranium, I may point out the progress made in the development of the tympano-Eustachian cavities. In the palatal view, with the inferior arches removed (Pl. LXV. fig. 5), we see that the seam along the middle of the palate is just becoming perfect; it is open, however, behind, and the posterior nares (*p.n*) open, still, scarcely behind the middle of the head; but in the back of the recess into which they open there is a neat round hole with a swollen edge, before, and at the sides. Looking well within this hole we see three lesser passages, one in front and one right and left. A bristle is shown passing from one of the side holes over the mucous membrane obliquely, outwards and backwards; it reappears in a curved hole behind the quadrate hinge (*q.c*); these passages are the median and lateral Eustachian tubes and the tympanic cavities (*m.eu*, *l.eu*, cl^1).

In the sectional views (Pl. LXV. figs. 6, 7) the air-cavity in the hind part of the basisphenoid (*b.s*) is shown, but not the opening below, as the section is more than half of the head; in fig. 6 the opening into the tympanic cavity (*ty.c*) is shown. These passages will be illustrated in their further development in the later stages.

The chondrocranium (Pl. LXV. figs. 6, 7, 8) is very similar to what has been described in the last stage; but some of the main bony tracts have appeared in the hind skull. The first of these is the basioccipital (*b.o*), which reaches more than halfway from the condyle to the pituitary space (*py*), but leaves a considerable tract of cartilage, behind, untouched.

The exoccipitals also (Pl. LXV. figs. 7, 8, Pl. LXVI. fig. 3, *e.o*) are now climbing up the sides of the occipital arch; they are a good distance yet from the basal piece (*b.o*), reach nearly to the top of the foramen magnum, and just touch the opisthotic region in front; the supraoccipital and the periotic regions are not ossified.

The next bone is the basisphenoid (*b.s*); this occupies the bottom of the pituitary cup, and runs backwards a little below; it is not of greater extent than the spheno-occipital synchondrosis behind it, and it does not reach far into the "postclinoid wall" (*p.cl*).

The description just given of the chondrocranium of the last stages might serve also for this, except that the passages for the lesser cranial nerves are more perfectly bounded by cartilage (Pl. LXV. figs. 7, 8, between II and V); in this stage I have studied the skull by *sections*. Here, also, I have figured the auditory capsules on the outer and inner sides, in lateral views (Pl. LXV. figs. 7, 8), and the nasal capsules have been worked out both by dissections and sections. The auditory capsules (Pl. LXV. figs. 7, 8) are quite unossified; they form relatively very large pyriform masses, with sinuous surfaces arising from the form of the membranous labyrinth within.

On their inner face (fig. 7) where the anterior canal dilates at its junction with the posterior, there is a crescentic aperture whose concavity looks upwards and backwards; this is the remnant of the original involution (*aq.v*). In front of this there is a large arched swelling caused by the anterior canal, and behind it another of less extent caused by the posterior canal; these are also seen on the outside (fig. 8, *p.s.c*). A gently sulcate tract separates the arched part on the inside from the swelling caused by the "sacculus;" then comes the shallow *meatus internus*, with one upper and two lower passages; the foremost of these latter is for the facial nerve (VII), the others for the auditory (VIII). Mesiad of these there is the swelling caused by the cochlea, best seen in the outer and lower views (Pl. LXV. fig. 8, and Pl. LXVI. fig. 3, *chl*) The large *pre-* and *post*auditory nerves (V, IX, X) pass through deep foramina, fore and aft;

a deep groove runs down inside between the fore edge of the capsule and the outturned selvedges of the hooked, overlapping alisphenoid (*al.s*). In section (Pl. LXVII. fig. 8) the auditory capsule is seen to be very distinct from the wide, swelling plate below—the double parachordal, with the uniting notochord and its ossifying sheath (*b.o*, *iv*, *nc*).

This section is in front of the supraoccipital cartilage; it cuts through the falcate otic process (*ot.p*) of the quadrate and its lower or articular part (*q*); the articular part of the mandible (*ar*) is seen *in situ*. Fitting into the fenestra ovalis (*fs.o*), the columella (*m.st*) is seen, behind it a narrow tract of cartilage is cut through, and then there is another opening, the fenestra rotunda (*f.r*). This section is through the mouth of the cochlea, and thus seems to show the *two* fenestræ as opening into *one* cavity. The fore part of the sacculus (*vb*) is cut across above and within, and above it, in the crest of the capsule, the neck of the first ampulla (*a.s.c*). The columella has its mediostapedial part (*m.st*) ossified, and its extrastapedial end (*e.st*) is seen rising outside the otic process of the quadrate. We must look further back for any rudiment of the "tegmen tympani" (Pl. LXV. fig. 8); it exists here merely as the projection of the canals.

The fenestræ in the walls of the skull differ from those in the Bird, and are of less extent than those in the Lizard; in the former the alisphenoid itself is fenestrate; here there is a large space between the orbito- and alisphenoids, well margined above by a band which is not found in the Bird; whilst a smaller band below divides that from another smaller fenestra between the hind part of the orbito-sphenoid and the presphenoid.

As I have just shown, the alisphenoid, instead of lying far from the auditory capsule, as in the Lizard, clings close to it, here, and is only separated from it by a chink. The postsphenoidal region is cut through in another section (Pl. LXVII. fig. 7) just at the back of the pituitary cup (*py*), which is seen to have some "acini" of the "gland" in it. Here the ossification (*b.s*) has reached the cup (Pl. LXV. figs. 6, 7, *b.s*); but the part where the *para*chordals pass into the *pro*chordals, laterally, is unossified; here the alisphenoids (*al.s*) are seen to be direct continuations of the basal (parachordal) plate. Above, the fenestra is cut across at its hind part, and the upper band (*u.o.al*) is strong and incurved.

The front angle of the otic process of the quadrate (*ot.p*) is seen in section, outside and below that band.

In the next section, through the front of the pituitary cup (Pl. LXVII. fig. 6, *py*), the apices of the trabeculæ (*tr*) are cut across, close in front of the growing basisphenoid bone (*b.s*). The optic nerves (II) are severed close below the lower band of cartilage, the lower orbito-alisphenoidal band (*l.o.al*); and above, at some distance, the upper band (*u.o.al*) is severed, where it is thickening towards its fore part.

Meckel's cartilage (*mk*) is seen in section also. In front of the pituitary body

(Pl. LXV. figs. 6–8, and Pl. LXVII. fig. 5) the three prochordal bands have united to form a rounded bar with a moderate crest; this is the part where the basi- and presphenoids pass into each other; the upper band (*u.o.al*) and the lower (*l.o.al*) are both seen in section at this part also.

The composition of the "anterior sphenoid" is well seen both in the side view (Pl. LXV. figs. 6–8) and in section (Pl. LXVII. figs. 3, 4, *i.tr*, *tr*, *o.s*). Near the optic nerves (fig. 5, II) the three elements are well fused together, but further forward (Pl. LXVII. fig. 3) they are seen more distinctly. The trabeculæ (*tr*) are very much flattened against the sides of the large, median, crested bar (*i.tr*), but at its upper part they thicken, and pass upwards, and a little outwards as the two orbito-sphenoidal plates (*o.s*); these are convex inside, below, and outside, above, and form a trough for the rhinencephala (C^{15}). Further forward (Pl. LXVII. fig. 2) the orbito-sphenoids (*o.s*) are separated from their root by a tract of membrane, and here the cornua trabeculæ (see fig. 1, *c.tr*) begin. Still further forward (Pl. LXV. figs. 6–8, and Pl. LXVII. fig. 1, *c*, *tr*) we see the thick wedge-like ends of the cornua (*c.tr*); beyond these the whole bar is formed by the intertrabecula (*i.tr*); this section is through the low part of the wall, under the olfactory lobes, and through the fore part of the orbito-sphenoids (*o.s*). The ethmoidal, or true olfactory region of the nasal capsule, forms a pair of irregularly pyriform pouches (Pl. LXV. fig. 8, and Pl. LXVI. figs. 9, 10, *al*, *e*), which are covered only by membrane for some distance. I find no "ethmo-palatine" rudiment upon the "pars plana" (*p.p*), or antorbital face of these pouches. Inside, both in the front of the ethmoidal region and in the back of the proper alinasal territory (Pl. LXVI. figs. 9, 8), there is an outgrowth of the cartilage which encloses, for some extent, two lesser spaces; this is the "inferior turbinal" (*i.tb*) in a very rudimentary condition; and the "upper turbinal" is represented by a fold above this (fig. 9, *u.tb*). At this part and in the next section (Pl. LXVI. fig. 7) the floor of the nasal capsule is free from the base of the septum (*s.n*); but in the next (fig. 6), a short distance behind the outer nostrils, the nasal floor and septum (*n.f*, *s.n*) are confluent, like the nasal roof (*al.n*); the wall here is incomplete.

When the nostrils are cut through (fig. 5) we see an upper cartilage or alinasal (*al.n*) confluent with the swelling floor in front of the septum; here the prenasal rostrum (*p.n*) or sagittiform end of the intertrabecula is cut across; it is nearly circular in section.

b. *Visceral Arches.*

The quadrate or upper part of the first visceral arch (Pl. LXV. fig. 8, and Pl. LXVI. figs. 1, 3, *q*) is very large, and is partly ossified.

The otic process (Pl. LXV. fig. 8, *ot.p*) has a rounded anterior knob, and a falcate hinder lobe which overhangs the first cleft. The anterior limb or "orbital process" has (*in this species*) scarcely any ascending process, but the pterygoid cartilage (*pg.c*) is long and pointed. The body is scooped behind, and a large semicircular notch is formed by the hind border; the articular part becomes an oblong sinuous condyle passing across, and a little forward, externally (Pl. LXV. figs. 5 & 8, *q*).

The quadrate bone (*q*) possesses the body of the cartilage, but not its outgrowths or processes; it is not *pneumatic* at present. The free articulo-Meckelian rod or mandible (Pl. LXV. fig. 8, *ar*, *mk*) is nearly as long as the skull, has a saddle-shaped condyloid facet (*ar.c*), a rounded angular process, a bony centre, the "articulare," and a long, terete, Meckelian rod, which is confluent with its fellow in front (Pl. LXVI. fig. 5, *mk*, *b.mn*).

In the coronoid region there is a small, notched, squarish plate of cartilage, the "coronoid cartilage" (*cr.c*); the rudiment of the continuous coronoid crest of the mandible in *Lepidosteus* and *Amia*. Meckel's cartilage is thickest in the middle, and is attenuated at each end.

Another remarkable *rudiment* (or *remnant*) is seen in the upper part of the first arch; this is an *extrapterygoid* facet (Pl. LXV. fig. 8, and Pl. LXVI. figs. 1 & 3, *pg.c'*); this is a tongue-shaped tract lying along the outer edge of the pterygoid bone, where it glides against the mandible; it is a partial reappearance of the large ichthyic pterygoid outgrowth.

I shall describe the hyoid arch in both the Alligator and Crocodile in this stage, which gives a *stapedio-hyoid* bar, almost precisely the counterpart of that of *Hatteria* (Pl. LXVIII. figs. 15, 16, Pl. LXIX. figs. 1–3; see also Huxley, Proc. Zool. Soc. 1869, p. 397, fig. 4).

In the Alligator (Pl. LXVIII. figs. 15, 16) the stapedial disk of the columella is very large and oval; *it has its own basistapedial centre* (*st*) on the inside of the disk. The mediostapedial bone (*m.st*) is dilated on the outside of the disk, and forms a shortish and slightly curved shaft, which reaches nearly to the distal dilatation of the columella; the segmental line seen at this part, in the earlier embryos, is gone. The bar itself is continued upwards and forwards, but grows into a large fan-shaped crest, with a ribbed free outer edge; this is the extrastapedial process (*e.st*). From its thick (axial) back, near its base, the suprastapedial process (*s.st'*) is given off; it is like a half-open fan, and grows upwards, inwards, and backwards (see Pl. LXV. fig. 8). Coalesced with this, but with the line of junction still evident, we see the suprastapedial cartilage (*s.st*), an ear-shaped flap, twice as large as its *stalk*, and having its narrow lower end free. A notch on the outer side of the broad, lower end of the extrastapedial receives the short, curved epihyal (*e.hy*), and this is joined to a notch on the hinder side of the broad upper end of the ceratohyal (*c.hy*), now membranous in its lower half, and therefore quite free from the mandible below. These parts are all continuous (see also in the irregular hyoid of another specimen, Pl. LXVIII. fig. 16), and only show the old seams of segmentation.

The most perfectly Hatterian condition is seen in the hyoid arch of an embryo Crocodile taken on July 27th (Pl. LXIX. fig. 1). In this elegant stapedio-hyoid structure the stapedial base (*st*) has its own *inner*, osseous centre, and a stout bony mediostapedial rod (*m.st*), whose dilated base is nearly of the same length as the outstanding bony bar. The two foliaceous outgrowths of this remarkable "pharyngohyal" grow, the one inside, upwards, backwards, and inwards; and the other outside, forwards, upwards, and outwards, very obliquely.

The broadening curved blade of the suprastapedial stalk (*s.st'*) has its outer face ribbed, and its broad, backwardly turned top confluent with the auriform suprastapedial segment (*s.st*), whose upper part is bilobate, its lower part rounded, and its proximal edge thick and solid. Together these parts describe an accurate semicircle by their lower edge.

The extrastapedial (*e.st*) is seen somewhat edgewise (see also fig. 2); both its inner and outer edges are ribbed, and the latter dilates into an elegant crescentic hook, above. Below, this process becomes twisted, narrower first, and then dilated into an oval interstapedial (*i.st*) disk, where it is confluent (with a trace of the junction left) with the arched band below, the epihyal (*e.hy*). This in turn is confluent with the ceratohyal (*c.hy*), but shows the joint. That joint is behind the broadened head of the lower bar, which is gradually attenuated, until it becomes a ligament, attached to the original point of confluence with the mandible.

This is not all; for the ceratohyal itself is half segmented in the middle; the lower part it will soon degenerate into a fibrous tract.

A week later on (August 4th) brings us towards the later changes of these parts (Pl. LXIX. figs. 2, 3), here the parts are also seen from the outside, but drawn out so as to display them better.

The oval stapedial plate, with its inner, central, growing bone (*st*), is very large, and has a rounded edge for the fenestra ovalis; the shaft, as in the last, is seen to arise much above the middle.

This almost straight, slowly attenuating rod, ends below the outgrowing distal, leafy growths; the suprastapedial (*s.st*) is figured within, and the extrastapedial (*e.st*) without.

All the old seams, or lines of segmentation, *have opened again*, with the exception of that across the columella (see Pl. LXVIII. figs. 10–14); this is like the dehiscence of "carpellary leaves" that begin in the bud as distinct members of the innermost whorl of a *flower*, then unite, and reopen, afterwards, to shed the seeds.

The main distal plate, extrastapedial (*e.st*), is like a bill-hook, but is dilated in an arcuate manner above and below; there is an articulation to the curved segment (epihyal, *e.hy*) which articulates below with the ceratohyal on one side of its dilated upper part; the lower part is lessening fast. The suprastapedial segment (*s.st*) is now clearly distinct again from the suprastapedial stem (*s.st'*); it has developed a pedate process inwards from the point of junction above.

The distal part of the second and third visceral arches of the embryo Alligator (Pl. LXV. fig. 9) shows a dilated basihyo-branchial plate (*h.br*), which is broad in front, notched behind, and has two rounded notches antero-externally; there is but little evidence of a hypohyal rudiment, except the dilated sides of the plate in front of the "first ceratobranchials" or thyrohyals (*c.br'*); these latter are inbent rods, largely ossified.

c. *Investing Bones.*

These were worked out in the largest embryos of the Alligator (Pls. LXVI., LXVII.); they are already very characteristic of the type, and are much in advance of what has been described in the third stage. The main fontanelle (Pl. LXVI. figs. 1 & 4, *fo*) is very large as yet; the parietals (*p*), only flank its sides as small ear-shaped plates; they have a projecting angle inwards, and look like squamosals. The frontals (*f*) form a sort of "beading" round the large orbits; the upper part is a narrow, crescentic band, gently widening from behind forwards. The largest part is the concave orbital flange, turned inwards along the whole length of the bone. The frontals overlap the parietals behind, and are overlapped by the prefrontals in front.

The latter bones (*p.f*) are convex and ear-shaped, with a scooped hind face against the eyeball in front; the two are their own width apart on the top of the head.

In front of these are the nasals (*n*); they are almost oblong, but are narrow in front; they have a concave fore margin obliquely fitted to the alæ nasi (*al.n*), and are pointed there at their inner edge.

The premaxillaries (*px*) form together a semicircle, broken in the middle, where there is a gap between them, showing the prenasal cartilage (*p.n*); these and the maxillaries have a double wall, a deep common alveolar groove, and fast-growing teeth in it.

On each side of the alveolar groove the maxillaries (*mx*) are well developed both externally and within; in the former region there is a large facial plate running from the premaxillary in front to a line below the optic nerve (II) behind; this suborbital part is narrow, scooped above, and pointed at the end. The palatine edge of the premaxillary is small, that of the maxillary is a large ingrowing plate, widest in the middle, but half its own width from its fellow. Between the maxillary and the prefrontal there is a small triangular bone applied to the lacrymal involution; this is the lacrymal bone (*l*). Close behind it there is a styloid bone, curved upwards in front, downwards behind, and having at its hinder third an ascending triangular process; this is the jugal (*j*). A similar process comes down from a bone above, finishing the postorbital rim; this is from the postorbital bone (*p.ob*), the upper part of which is a crescentic shell with an outer and an inner toothed process. The relation of the postorbital to the parietal is antero-external; it clamps the frontal, parietal, jugal, and squamosal. The latter bone (*sq*) is a large convex trowel, with its "handle," in front, overlapped by the postorbital.

These two bones are separated from the skull-wall by a deep chink—the temporal space; but, behind, the squamosal strongly clamps the auditory capsule, and by its sinuous lower edge it forms a large overlapping eave to the tympanic cavity; this is oblique, dipping backwards.

The jugal does not finish the facial series of splints in the Crocodilia; another bone, the quadrato-jugal (*q.j*), overlaps the quadrate, and is in turn overlapped by the styliform jugal; the shape of this bone is falcate, its sharp blade running obliquely upwards and forwards, strongly binding the antero-inferior region of the quadrate (*q*).

The palatine region (Pl. LXVI. fig. 3) is now becoming well floored with bone; but there is a large trowel-shaped tract of the chondrocranium unfloored in the middle; its narrow end is behind, and it is lost between the pterygoids (*pg*). The palatines (*pa*) are here nearer each other than the maxillaries; but the vomers (*v*) and the basal bar (*p.e, p.s*) can be seen between them at their closest part. The amount of bony deposit in these investing tracts, and its relation to the endocranium is to be seen in the sectional views (Pls. LXVI., LXVII.); but these views are most important for elucidating the palatine region. Seen from below (Pl. LXVI. fig. 3) the palatine bones are like falcate blades, with their broad fore end applied obliquely to the gently scooped margin of the palatine plate of the maxillary, right and left.

The outline of the palatine bones is convex in front and externally, convex also along their inner edge, and also notched there in front, and concave on their postero-external margin; their hinder part is a sharp hook turned outwards.

Their exposed upper surface (Pl. LXVI. figs. 1 & 4) is of less extent than the palatal part; their outer edge is thickening into a rather solid tract of bone. All this will be better understood by reference, also, to the sections (Pl. LXVI. fig. 10, and Pl. LXVII. figs. 1. 2, *pa*); in these also will be seen the thickness, width, and relations of the vomers (*v*).

These latter bones (Pl. LXVI. fig. 3) are long, flat styles, curved, and placed back to back. In front (Pl. LXVI. fig. 9, *v*) they are V-shaped in section, but afterwards flat, and having their plane dipping towards each other (fig. 10, *v*). They overlap the maxillary palatine plate at their folded fore end; behind, they reach the pterygoids (*pg*). These latter bones (Pl. LXVI. figs. 1 & 3, and Pl. LXVII. figs. 5–7, *sections*) are two coadapted wings of bone, binding the palatine series well together, and forming a strong underfloor to the basisphenoidal region of the skull. The pterygoid suture is imperfect before and behind; in front, the slightly diverging processes are subtubular, and enclose the narial passage (Pl. LXVII. fig. 6, *pg*, *i.n*); this is where the palatines (*pa*) end. Then (Pl. LXVI. fig. 3, and Pl. LXVII. fig. 7, *pg*) these bones spread out into broad wings, a rounded notch lying between their widest expansion and the basicranial hinder part. The hind margin of the two bones is notched in the middle, then sinuous, and then becomes dilated outwards and backwards to embrace the fore part of the auditory capsules and their enclosing bony plates, the "basitemporals" (*b.t*). The outspread fore wings of the pterygoids (Pl. LXVI. fig. 1, *pg*) descend as well as diverge, and are finished externally with a blunt retral hook. This part is ridged in the middle, supero-externally, and scooped fore and aft; against this ridge lies the crescentic cartilaginous facet already spoken of; the direction of both is with the convex edge looking forwards and downwards. A bone, with the outline of an hourglass, fits by its top to the inside of the maxillo-jugal suture, and by its base lies under the fore part of the pterygoid wing, obliquely; this is the "os transversum" or "transpalatine" (*t.pa*), with the maxillary and palatine it forms a large oval "palatine fenestra."

All these bones were to be seen in the third stage; but between the pterygoid and the unossified auditory capsules, right and left of the basisphenoid, there is a pair of new investing bones; these are the "basitemporals" (Pl. LXVI. fig. 3, *b.t*); they are uncinate shells of bone with a thin, toothed hinder margin, and they form a floor to the cochlear pouch (*chl*). These were first found and described by me in the *Chick* (see Trans. Zool. Soc. vol. iv. p. 280, and Phil. Trans. 1869, pls. 72–77, *b.t*); I have not been able to find these "parostoses" distinct in any other kind of Reptile; in the Mammalia they are manifestly represented by the "lingulæ sphenoidales," and these have their largest development in *Cavia cobaya*.

The parostoses of the mandible (Pl. LXVI. figs. 1, 2) are now well developed; the dentary (*d*) is by far the largest, the splenial (*sp*) is a very long splint, the coronoid (*cr*) is a small angular patch applied to the inner face of the "coronoid cartilage" (*cr.c*), and the supraangular and angular (*s.ag*, *ag*) are styliform, and send their long sharp ends forward, over and under the mandibular fenestra (*mn.f*), which is large and oval; these mandibular splints are also figured in the sections (Pls. LXVI., LXVII.).

6th Stage. *Embryo of* Crocodilus palustris, *taken August 8th*, $5\frac{3}{4}$ *inches long*.

In this stage we find the *periotic bones* begun, and indeed rapidly developing; an inner view of a vertical section (Pl. LXIX. fig. 6) shows these three bones, and also the alisphenoid and supraoccipital; the bones that had begun in the last stage have grown very much.

The basioccipital bone (*b.o*) now forms a large, rhomboidal plate, separated from the exoccipitals (*e.o*) by a widish synchondrosis, a tract of cartilage which runs also across, in front, between the basioccipital and basisphenoid (*b.s*). At that part the basis cranii is pneumatic, and the median part of the tympanic Eustachian labyrinth is seen there.

A remnant of the notochord still exists in the basioccipital; it dimples the large transverse condyle (*oc.c*). The exoccipitals (figs. 5, 6, *e.o*) run to the top of the foramen magnum, grow well forward towards the auditory capsule, are separated by a widish tract below from the basal, and also by a wide tract above from the upper bone of the arch (*b.o*, *s.o*).

The hypoglossal nerve (XII) behind, and a vein in front of it, pierce the base of the exoccipital; it is notched for the vagus nerve (X). The supraoccipital (*s.o*) is a rhomboidal plate formed in the hind roof-cartilage; it is rather thick already, ready to become pneumatic; it articulates at its antero-inferior edge with the epiotic (*ep*).

The basisphenoid is equal to the basioccipital in size; it is entirely surrounded by cartilage, which intervenes between it and the basioccipital behind, the prootic (*pr.o*) above and behind, and the alisphenoid (*al.s*) above and in front. There is no bone in front of it, below, for the rest of the basicranial axis remains cartilaginous.

The fore part of the basisphenoid (*b.s*) is hollowed out for the pituitary body and internal carotid arteries, the hind part is pneumatic, the cavity running into the basioccipital. The bony matter is fast affecting the posterior clinoid wall; and outside that wall, a tract of cartilage intervening, there is an irregularly oblong bony tract on the lower half of the alisphenoidal wall (*al.s*); this centre is pointed above, and square below, it just reaches the large foramen ovale (V) behind. For the rest, the basicranial axis and nasal septum (*p.s, p.e, s.n, p.n*) form a relatively larger tract than in the last stage.

The prootic bone (*pr.o*) is a thin ectosteal shell in the front wall of the auditory capsule; it runs upwards and backwards, with deep toothings, towards the meatus internus (VII, VIII) and the anterior ampulla (*a.s.c*). There is then on the arched fore edge of the capsule an almost equal length of cartilage; above that, the arch of the anterior, and the beginning of the posterior, canal are covered with the second bony tract, the epiotic (*ep*); the upper edge of this bone forms a suture with the superoccipital.

Against the middle of the concave face of the exoccipital, on the inside, we see a third lozenge-shaped bony tract; this is the opisthotic (*op*); it runs round behind, close outside the ampulla of the posterior canal, and is above and behind the great chink for the glosso-pharyngeal and vagus nerves (IX, X). These periotic centres appear to be rather more inside than outside; they begin near the edge of the somewhat flattened capsule, and occupy about one fourth of its large sinuous superficies.

All but the projecting angles of the great quadrate (Pl. LXIX. fig. 5, *q*) is ossified, and this bony centre is becoming pneumatic. Also the postero-external face is much more scooped, and the notch behind is semicircular.

The soft fore angle of the otic process (*ot.p*) turns upwards, the hinder corner downwards. A considerable core of cartilage remains over the lower condyle (*q.c*), and the forks of the "orbital process" are unossified;" the upper spur is the "ascending process" (*a.p*), and the front spur is the rudimentary "pterygoid cartilage" (*pg.c*).

Both the lateral cranial fenestræ are pyriform; the lower is now two thirds the size of the upper. The orbito-sphenoidal plate is relatively less; a very small spike-shaped rudiment of the anterior "tegmen cranii" exists, growing backwards from the top of the perpendicular ethmoid (*p.e*).

There is a small foramen below the upper fenestra; and a space for the lesser cranial nerves below and behind the optic passage (II), which is circular, and nearly as large as the foramen ovale (V).

In this stage the various canals or passages can be well seen (Pl. LXX. fig. 8); in the figure the hinder part of the soft palate is cut away so as to expose the "posterior nares" (*i.n*), which open into a circular recess. Behind them there is a smaller notched fold of membrane, and over the notch a round median passage; this is the middle Eustachian passage (*m.eu*), it opens into the basis cranii.

At a short distance outside this there is, on each side, a curved valvular opening; the broader end of each is behind, and these ends approximate; the convex edge of each is postero-lateral; these paired openings are the lateral Eustachian openings (*l.eu*), and run directly into the main tympanic cavity.

7th Stage. *Nearly ripe, and ripe embryos of* Crocodilus palustris, *taken from September 4th to September* 8*th, total length* 10 *to* 10½ *inches; and ripe embryos of* Crocodilus ——?, sp.

a. *Endocranium.*

The general form of the parts of the endocranium alters but little during the last month—August 8th to September 8th; its changes are mainly increase of size and consolidation of the various regions, especially the bony centres. The two paired and the two unpaired bony tracts of the occipital arch (Pl. LXIX. figs. 7, 8, *e.o*, *s.o*, *b.o*) now form a strong ring of bone, with very limited synchondroses dividing its elements. The basioccipital (*b.o*) does not reach the basisphenoid (*b.s*), nor fill all the cartilage belonging to it behind; thus the condyle (*oc.c*) is a solid mass of cartilage, and not a mere articular plastering left on the bone. The form of the bone is roughly pentagonal (Pl. LXX. figs. 1 & 3, *b.o*), and it is separated from the other bones by narrow tracts of cartilage. It is somewhat grooved in the middle, below, and mamillate right and left, and its gradually narrowing hinder part is imbedded in the reniform condyle, whose "hilus" is filled with the remnant of the notochord (*n.c*). A common round opening leads into both this bone and the basisphenoid, for one pneumatic cavity occupies both; the opening is the "middle Eustachian passage" (*m.eu*). In the front of each lateral angle there is another, lesser passage, which is the *posterior opening* of the "lateral Eustachian tube" or passage (*l.eu*). This opens into a lateral chink behind the basitemporal plate (*b.t*) (Pl. LXX. figs. 3, 4, & 8, *l.eu*), and this chink leads also into the excavated basisphenoid, the *anterior opening* of the "lateral Eustachian tube." The large, winged exoccipitals (*e.o*) and their synchondrosial cartilages complete the ring over the foramen magnum (Pl. LXIX. fig. 11, and Pl. LXX. figs. 1 & 3, *f.m*). They are large, irregular, multangular shells of bone—shells both in their general convexo-concave form, and also because they are hollow or pneumatic. They are riddled with holes on their lower surface, but each hole has its meaning and function.

The hindermost of these, nearest the condyle, is for the hypoglossal nerve (XII), then there is a small passage for a vein, and outside in front of that a hollow with two passages, these are for the vagus and glosso-pharyngeal nerve (X, IX). At the antero-internal angle there is a notable round hole; this leads to a more or less perfect bony canal for the internal carotid artery (*i.c*), which reappears in the basisphenoid, and ends in the bottom of the pituitary cup (Pl. LXX. fig. 4, *i.c*; here the basisphenoidal part of the canal is drawn as having a bristle passed through it).

The two large tracts of the exoccipital that unite, respectively, with the basioccipital, superoccipital, and opisthotic (*op*) are not faced with more than a trace of cementing cartilage; for large cavities have been already formed. But the tympano-Eustachian labyrinth communicates with all these posterior cranial and auditory bones; the foremost of these spaces, on the opisthotic margin, is seen in the partly disarticulated skull (Pl. LXX. fig. 3, *e.o*). The inner wall of the exoccipital (Pl. LXIX. figs. 7, 8, *e.o*) is a convex tract, narrow in the middle and dilated above and below; its posterior margin is sinuous, and its front margin is bevelled and oblique behind the large occipito-auditory chink, which below lets out the ninth and tenth nerves (IX, X). The opisthotic (*op*) bulges towards its fore margin, and is ankylosed to the exoccipital, now, in front of the chink, and projects inwards as a shell of bone, which is angulate in front. Below (Pl. LXIX. fig. 8, *op*) it is narrower, and forms a complete loop of bone round the fenestra rotunda (*f.r*) and divides it from the *f. ovalis* (*fs.o*).

The supraoccipital is entirely on the roof of the skull (Pls. LXIX. and LXX. *s.o*); it also is compound, now, for it has coalesced with the right and left epiotics (*ep*). It is rhomboidal in form, and its hinder projection is separated by a wedge of cartilage from the foramen magnum; cartilage also can be seen within it behind (Pl. LXIX. figs. 7, 8, *s.o*), and also above over its junction with the epiotics (Pl. LXX. fig. 6, *s.o*, *ep*). It is concave in the middle and scooped right and left in its thick exposed hind part; but in front, where it is covered by the parietals (Pl. LXX. fig. 2, *p*, *s.o*), it is thin, has a fenestra on each side, and is crenate along its thin front margin. In front, as is shown in the section (Pl. LXIX. figs. 7, 8, *s.o*), it is pneumatic, and its cavity opens freely into that of the right and left epiotic, and at the two fenestræ (Pl. LXX. fig. 6, *s.o*) the general cavity is shut in by the parietals, only. The epiotics (*ep*) finish this part of the roof; they are hollow shells, with their concavity looking inwards; this swelling contains the junction of the anterior and posterior canals. In the inside views (Pl. LXIX. figs. 7, 8) the general synchondrosial tract between the periotic elements is shown; it is triradiate, and is large and swollen where the three rays meet.

The union of these two canals is imbedded in the thick inner bone close to the cementing cartilage; but there is a thin table of bone above, and then a large pneumatic cavity between it and the part which contains its share of the labyrinth. In the upper view of the epiotico-superoccipital bone (Pl. LXX. fig. 6) a bristle is shown as traversing this large upper pneumatic cavity, which is open under the parietal, and shows itself again, above, antero-externally, as indicated by the bristle, which is figured as emerging from the prootic margin.

The prootic (Pl. LXIX. figs. 7, 8, *pr.o*), or foremost of the auditory bony centres, is nearly the size of the other two combined, and is not ankylosed to any neighbour bone.

This element contains the ampullæ and part of the arch of both the anterior and horizontal canals (*a.s.c*, *h.s.c*); is perforated for the seventh and eight nerves (VII, VIII); and is notched by the fifth nerve (V) and by the stapedial plate (*st*).

Its fore margin is almost vertical, but its hind margin swells into the largest of the three shells of bone that bound the triradiate synchondrosis. Above, its oblique edge is finished by cartilage, where the alisphenoidal cartilage joins on to the capsule; below, it is separated from the basisphenoid by another similar tract. It binds on to a notch of the alisphenoid above, and then they are both notched to form the large foramen ovale (V). Postero-inferiorly there is an oblique notch a little higher up, finished by cartilage above; this is the fore edge of the fenestra ovalis (*fs.o*).

This swollen shell forms a sort of penthouse over the "meatus internus;" the two passages for the eighth nerve (fig. 7, VIII) lie obliquely under this part, and below and in front of them we see the single hole for the facial nerve (VII). The bone under that hole is rounded; it is scooped above and below the shell in front; this is all *inside*. *Outside* (Pl. LXX. fig. 11) there is a thin loop of bone above, where the air-cell of the epiotic ends; the rest of the outer surface is sinuous, answering to the membranous labyrinth within. Below, a crescentic wedge of bone grows obliquely forwards and outwards, and forms with the main plate a large open channel; this channel opens freely into the air-cavity inside the quadrate bone—a *labyrinth* in itself. The facial nerve (VII) emerges in the top of this tympanic channel; the epiotic air-cell evidently ends in the crescentic sulcus between the thin loop of bone and the body of the prootic, supero-externally.

The alisphenoid (Pl. LXIX. fig. 7, *al.s*) is an obliquely oblong bone, leaning forward, somewhat, in front of the prootic, and locked by it above, the tooth of the latter fitting into a notch of the former. It is bordered by cartilage above and at all its four angles; its hinder margin is thick and pneumatic, the opening being into the great cavity in the basisphenoid. The fore margin is thin and scooped inside, and its oblique, almost straight free edge bounds the large upper "lateral fenestra," which is now a long oval, with the broader end above. The postero-inferior edge is concave, to finish the foramen ovale (V); in front the dilated base of the bone rises forwards nearly up to the optic foramen (II); then the cartilage runs over the optic nerve and joins the postero-inferior angle of the orbito-sphenoid (*o.s*). The hollow fore part of the alisphenoid is filled with the optic lobes; the bone is thin at that part, and bulges, correspondingly, outside.

Both the lateral fenestræ are relatively lesser than in the last stage (Pl. LXIX. figs. 6, 7); but, with the exception of the basisphenoid, the rest of the endocranium is entirely cartilaginous, and differs but little from what is seen in the last two stages.

The keystone of the inverted postsphenoidal arch is a very large bone, and has already become *compound*; for the basitemporals have united with its lower table (Pl. LXX. figs. 3–5, *b.t*, *b.s*). These are round shells of bone behind the pterygoid wings; the bony scrolls for the internal carotids (*i.c*) lie over them. The true basisphenoid (*b.s*) is composed of a wide square hind part, and of a narrow fore part, which has the outline of a truncated cone; it is, however, flat above and rounded below. The ossification in front stops suddenly against the presphenoidal cartilage (*p.s*); behind, it has a gently concave form, and is separated from the convex fore margin of the basioccipital (*b.o*). *Beneath* the narrow synchondrosis is the middle Eustachian opening (*m.eu*), and on each side of that the bony matter projects as two small ears inside the larger ears formed by the basitemporals. The basisphenoid also gives off a pair of lateral ears before it narrows in close to the middle; at that part there are two smallish foramina looking forwards. The middle line, below, of the hind part is grooved, the sides are convex. Above (Pl. LXX. fig. 4) the hollow and shelving upper table is square, with the corners trimmed off; the sides next to the cartilage are straight; both the hinder and the free front edge are gently cut away in an arcuate manner. The fore edge is tilted upwards; it is the postclinoid wall (*p.cl*); behind its shelving face the floor is gently hollowed for the medulla oblongata, but it has a slight median ridge behind. The pituitary cup is oblique, and looks forwards and upwards; it has two large openings below and behind for the emergence of the internal carotids (*i.c*). The body of the bone behind the pituitary cup is one large air-cell, which opens antero-laterally into the air-cavity of each alisphenoid into the common middle opening (*m.eu*). That part of the labyrinth of pneumatic passages which is common to the outside of the prootic and the inside of the quadrate also opens into the side of the basisphenoid at its middle. Thus the cavity of the bone has five communications with the labyrinth, right and left and behind. The specialization of the *first pair of clefts* is so great as to throw them both into one complex system of passages, pervading the whole hind skull, auditory capsules included, and including also, as I shall soon show, the hinder or articular part of the mandibular rods. The internal carotids enter the skull in front of the pouches where the lateral Eustachian tubes communicate with the pneumatic openings of the basioccipital (Pl. LXX. fig. 3, *l.eu*, *b.o*).

A transverse section through the hind skull, exposing the tympanic cavity (*c.ty*), with its traversing columella (Pl. LXXI. fig. 7, *co*), shows the relation of the basisphenoid to the fore part of the auditory labyrinth (*a.s.c*, *vb*), and the manner in which the pneumatic passages enter the quadrate (*q*), externally, and the basis cranii within.

In the next section (Pl. LXXI. fig. 6) the alisphenoid (*al.s*) is shown as cut down the middle immediately above the fore part of the pituitary body (*py*) and the infundibulum (*inf*).

But the widest part of the cranial cavity is across the thin bulging part of the alisphenoids (Pl. LXXI. fig. 5, *al.s*); at this part they are ossified to their top edge, but below have a soft tract which ends a little above the presphenoid (*p.s*). Passing still further forwards (Pl. LXIX. fig. 7, and Pl. LXXI. fig. 4) we see how the three cartilages have built the large orbito-nasal dividing wall, the main mass of which has been formed by the intertrabeculă (*i.tr*), which is covered with a plaster of cartilage formed by the trabeculæ (*tr*), that thicken again at the coping of the wall, and then spring upwards and outwards to form the sides of the chamber for the fore brain (C^{1a}). These diverging plates are the orbito-sphenoids (*o.s*); they narrow rapidly in front, and end in free points right and left of the olfactory lobes. The double chamber for these lobes (I) is cut across in the next section (fig. 3), and the vertical cartilage at this part is low, for there is a rounded gap in the wall here (Pl. LXIX. fig. 7), which is the perpendicular ethmoid (*p.e*). Right and left of this low part of wall the postero-inferior part of the olfactory capsule is cut across, and the hinder portion of the inferior turbinal (*i.tb*) is shown.

The next section (Pl. LXXI. fig. 2) shows a higher septum (*s.n*), with the roof, walls, and floor of the nasal capsule; above, these cartilages are continuous, but, below, the upturned floor (*n.f*) is free; the curious tubular inferior turbinal (*i.tb*) is shown inside the bulging lower wall (*n.w*).

Still further forwards (Pl. LXXI. fig. 1) the inferior turbinal is missed, and the sinuous walls are confluent with the septum both above and below.

Close behind the alæ nasi (Pl. LXX. fig. 13) the aliseptals (*al.s*) form merely two round tubes, their dividing wall (*s.n*) being very low. But the narial valves, confluent with the olfactory capsule (Pl. LXX. figs. 2, 12, *al.n*), are thin coils of cartilage that belong to the "superficial" category, but early unite with the capsules; they lie over the prenasal spike (*p.n*).

The partial vertical section (Pl. LXIX. fig. 7) is *more* than half the skull; in another figure (Pl. LXX. fig. 9) *less* than half is shown, and thus the nasal cavity of the right side is laid open. The transverse sections of the half-ripe Alligator (Pl. LXVI. figs. 5–10) help us here, as they show the ethmoidal region better.

The long bulging part in front (Pl. LXX. fig. 9) is a mere fold of the wall, the next is the "upper turbinal" (*u.tb*); it, however, is formed merely by a special infolding of the aliethmoidal wall (Pl. LXVI. fig. 9, *u.tb*), which in that section seems to be a distinct cartilage, midway from side to side and from top to bottom, and having its convex face looking inwards. This fold lies in front of the upper part of the oblique "pars plana" (Pl. LXVI. fig. 10, *p.p*) (the lateral ethmoidal antorbital wall), whilst the inferior turbinal (*i.tb*), which is a single tube behind (Pl. LXXI. figs. 2, 3), and an imperfect double tube further forwards, lies in a postero-inferior position (Pl. LXX. fig. 9). This part is very strong directly in front of the pars plana (Pl. LXXI. fig. 3, *i.tb*, and Pl. LXVI. fig. 10, *p.p*).

b. *Visceral Arches.*

The lower jaw is now as long as the rest of the skull (Pl. LXIX. fig. 9), the facet on the quadrate (*q.c*) being far back, and the angle of the lower jaw well developed. The quadrate (*q*) is very large; it occupies most of the side of the hind skull, and is as broad as that part of the basis cranii against which it abuts.

It is bound in and covered by strong outer plates of bone (Pls. LXIX. & LXX., *q*, *sq*, *q.j*), and only shows itself between these tracts below (Pl. LXX. fig. 1); the inner (or lower) face of the quadrate is seen to be very broad and somewhat concave. When cleared of its surroundings, and its outer wall removed (Pl. LXX. fig. 7), this bone shows large pneumatic cavities that traverse every part where the thickness is sufficient; on the inner face the table is very imperfect, and without any paring away shows the large air-cavities; they open freely into the *first* (*tympanic*) cleft. The middle third of its hind margin is notched, so as to form a large circular opening, finished behind by the hyoid cartilages; through this passage the columella escapes to lie on the hollow outer face of the quadrate. This bone is roughly four-sided, but the upper edge, or otic process, is extended fore and aft, and these rounded angles are not yet ossified. The hind margin is generally concave, but has the large notch in it; the lower is sinuous, ending behind in the large cylindroidal condyle (*q.c*), and in front runs to the end of the "orbital process," which is not yet ossified at the forked end. The ascending and pterygoid spurs (*a.p.*, *pg.c*) are now very short. Above these, on the fore edge, there is a toothed process on an outline which is gently concave. A thick rib of bone, partly cut away in the specimen figured (Pl. LXX. fig. 7), runs obliquely downwards and backwards from the front angle above to the fore edge of the articular condyle (*q.c*). The upper edge is also developed into a rounded balk of bony substance; thus the postero-external face of the bone forms a large shallow crescentic space, over which the tight tympanic membrane is drawn, and under which, at the middle of its upper part, the extrastapedial end of the columella (*e.st*) projects; this is *analogous* to the "manubrium mallei," but its *homology* with it is doubtful. A large air-cell runs inside the front oblique ridge, and a lesser cavity is seen below the hind notch; the pneumatic opening of this lesser cavity is halfway down the solid part under the notch. From that aperture there proceeds a membranous tube, which forms a communication with a similar aperture on the top of the articular region of the mandible close behind the joint; this tube is the "siphonium" (Nitzsch). In the figure a bristle is shown running through the upper space; below there is a large bilobate cavity in the "os articulare" (*ar*); this is the lowermost and the hindermost part of the extensive tympano-Eustachian labyrinth, formed by specialization of the "first visceral cleft."

In front of that hollow bony centre the mandible is a soft and terete rod, coalesced with its fellow at the chin (Pl. LXX. figs. 12, 13, Pl. LXXI. figs. 1, 2, 5, 7, *mk*). In the coronoid region the rudimentary coronoid tract of cartilage is still seen facing the mandible, where it would chafe against the huge wing of the pterygoid bone, that bone having also a facing of pterygoid cartilage (Pl. LXIX. figs. 9–11, Pl. LXX. fig. 1, and Pl. LXXI. fig. 7, *cr.c*, *pg.c*).

The upper elements of the hyoidal arch (Pl. LXIX. fig. 4, Pl. LXX. fig. 7, and Pl. LXXI. fig. 7) are now seen as distinct and, for the most part, reduced and arrested nuclei of cartilage. But the columella itself is a continuous half-bony rod, and has lost its early segmental tract; it has also become fused, proximally, as one bony tract with the stapedial centre (Pl. LXIX. fig. 4, *st*, *m.st*). The bony shaft ends where the foliaceous forks begin; that lobe which is more directly a continuation of the primary (*pharyngo-hyal*) rod is the extrastapedial (*e.st*); it is falcate, with a free retral hook and a terminal crescentic dilatation. The suprastapedial stalk (*s.st'*) passes inwards, upwards, and backwards, and is a broad flap with a pedate free end, the "toe" of which is above. Behind, and a little below it, and quite detached backwards from it, is the pyriform suprastapedial segment (*s.st*), one of the upper links of the proper hyoid chain.

To its broad lower end the epihyal, once more free, is attached by ligamentous fibres; it is a thickish nodule, with its lower end split; it is attached by its inner face to the sheath of the facial nerve (VII), the hinder fork of which emerges beneath it and the next nucleus; *through the Crocodilian representative* of the "stylomastoid foramen" the great branch (VII) can be seen crossing the medio-stapedial, and running downwards.

In front of the main nerve, but still behind the cleft, we see the remains of the main hyoid bar or ceratohyal (*c.hy*); it is like an arrested rib, with a capitular and a tubercular process. The two lower nuclei both rest upon the lower part of the quadrate, behind, where the great semicircular tympanic notch is finished below (Pl. LXIX. fig. 4, *q*, and Pl. LXX. fig. 7). Close behind the ceratohyal we see the unossified free edge of the projecting "paroccipital" (see also Pl. LXX. fig. 3, *e.o*); this is the part which in the Bird is developed so as to form a sort of cranial tympanic "bulla," but whose office is largely held in the Crocodile by the quadrate bone; here the main cavity lies forwards, in the Bird it lies backwards.

The distal part of the hyoid arch is only a *region* of the common distal rudiment of the hyoid and the "first branchial" arch. There is a median cartilaginous, and a pair of lateral ossified, tracts; the former is a wide *scoop*, round in front, notched at the sides, and circularly emarginate behind. The side rods are the first "ceratobranchials" or "thyrohyals" (Pl. LXX. fig. 10, *c.br'*); these are sigmoid rods, with a hooked, soft, free end, turning inwards. The tendency to form a lobulate hypohyal was arrested, and the whole median plate is merely developed as a wide, concave "basihyo-branchial" (*h.br*).

c. *The Investing Bones.*

Since the 5th stage (Pl. LXVI.) the outer bones have grown so as to finish a skull which is a very perfect miniature of that of the adult Crocodilian (Pls. LXIX.–LXXI.). The only instance of ankylosis is that of the basitemporals (Pl. LXX. figs. 1, 3, 5, *b.t*) with the basisphenoid (*b.s*).

The upper fontanelle (Pl. LXX. fig. 2) is now completely obliterated, and the parietals and squamosals (*p*, *sq*) almost cover the hind skull. In the palate also (Pl. LXX. fig. 1) the palatines (*pa*) have hidden the vomers, and the pterygoids (*pg*) have united along the middle, and even coalesced behind and over the posterior nares (*i. n*); between these passages the united bones form a small styloid partition. Nearly half the median part of the pterygoids is united by suture to form a continuation of the "hard palate," which in front is formed by the premaxillaries and the maxillaries (*px*, *mx*), and in the middle by the long, narrow, subtubular palatines (*pa*). The pterygoids can still be peeled off the basisphenoid in ripe (or nearly ripe) young (Pl. LXX. figs. 4, 5, *pg*, *b.s*). When the lower bony floor has been removed (Pl. LXX. fig. 3), the relation of the vomers (*v*), palatines (*pa*), and pterygoids (*pg*) to the basis cranii is shown. At first the vomers appear to be merely styloid bones, with their pointed end behind; but the pointed part has a thin curved flange, which is coadapted to the upper plate of the palatine of the same side. The pterygoids run forward between the vomers, and end there as sharp styles; they are *scoops*, with their hollow part downwards; further back, they unite into one, with a median crest looking downwards. All this is in the fore half; behind, these bones grow into deep wide wings, but up to the posterior nares they are tubular.

The lacrymal bone (Pl. LXX. fig. 2, *l*) has completed its tube. The bones of the hind face have finished the temporal and zygomatic arches, also the splints of the mandible (Pl. LXIX. figs. 9, 10) are fairly complete.

The sectional views (Pl. LXX. figs. 12, 13) show the thickness of the splint-bones, and their relation to the endocranial elements.

8th Stage. *Adult Crocodiles and Alligators.*

For descriptions of the skull of the adult I must refer the reader to the works mentioned in the "Bibliographical list" (p. 264), and especially to Professor Miall's valuable "Study." That work, with the actual skull of a full-grown Crocodilian, will enable the worker to finish this "demonstration."

General Remarks.

A more difficult task will be the comparison of the skull of this type in its various stages with the skulls of other Sauropsida in their various stages, and then to see how these *oviparous*, *amniotic* types, each in their own way, specialize their skulls and from the most similar elements develop such dissimilar skulls as those of a Snake, a Tortoise, a Lizard, a Crocodile, and a Bird.

I am able now to refer the reader to memoirs on all these (including the present paper); they are to be found in the 'Transactions' of the Microscopical, Linnean, and Royal Societies, of this Society and in the first volume of the 'Reports of the Challenger' (that on the skull of the Sea-Turtle).

It seems therefore that, to give completeness to the present paper, I ought to point out the more important modifications seen in the skull of the Sauropsida—how that skull is a mere specialization of the underlying *Ichthyic* type, and in what manner and degree it gives promise and prophecy of the highest of all skulls, viz. that of the Mammal. It is hardly necessary for me to state that I do not consider this last kind as arising from a type *directly overlying* the Sauropsida. The Mammalia form another branch of the *Amniota*, which has a separate root, and has, on the whole, a much higher culmination. In some very important things the skull of the Anurous Amphibian forms a better leading-step to that of the Mammal than any to be seen in Reptiles and Birds.

The highest of the many branches of the Sauropsidian stock is the *Passerine* form; but there is no crossing over from that to the Mammalia possible; we must slide down the whole of the vertebrate trunk, to its very root, before we are in a position to find the first shoot that grew Mammal-ward; this, perchance, was quite as low as the point from which the Sauropsida grew.

Summary.

As to the *first stage* it is scarcely necessary to point out the extreme similarity of the early embryo of the Crocodilian, not only to that of the other Sauropsida, but also to that of every other vertebrate type.

The cartilage at this stage is becoming solid, the sense-capsules are seen to be all separately formed, and the basis cranii can be made out, although it is in a very primordial condition. As in the Axolotl, the *pro*chordal tracts are merely small horns budding out from the large *para*chordal plates. But the rapid growth of the hemispheres, the outgrowing optic vesicles and olfactory lobes—all developments of the vesicular fore brain—is attended with an equal amount of prepituitary skull-growth, and in the *second stage* the *pro*chordal outgrowths are equal in length to the proper axial tracts, or *para*chordal plates. These latter run with the notochord into the hollow of the folded mid brain, but not beyond it; for that azygous axial rod bends downwards a little, as in the Chelonians and Elasmobranchs, but the mesocephalic flexure affects it less than it does the overlying brain-mass; it is arrested in its forward (and upward) growth. This partial arrest or suppression of the front part of the notochord is correlated with a great and, as it were, sudden development forwards and upwards of the investing basal cartilage.

The part which grows *upwards* appears to me to be the true end of the paired elements of the skeletal axis; and it is this part, viz. the large sloping "postclinoid" wall, which gives rise to the neural laminæ of the hinder sphenoidal region, the alisphenoids. Behind, the occipital ring is directly formed as an upgrowth, right and left, from the parachordal plates, and the want of continuity of the pre- and post-auditory walls is due to the intrusion of the large auditory capsules, which push the fifth and seventh nerves forwards, and the ninth and tenth nerves backwards. The proper termination of the primary neural and skeletal axes appears to me to be just where the "infundibulum" grows down to meet the oral involution (pituitary rudiment), and where the bulbous end of the hook of the notochord is seen. The hemispheres now rest upon the large adze-shaped front wings of the sphenoid (orbito-sphenoids), and these wings are direct upgrowths of the paired trabeculæ, which grow, like *new shoots*, from the under surface of the upturned parachordals.

In front of the pituitary involution, there being no axial notochord, a *new axis* appears; this *preaxial rod*, the "intertrabecula," is very large indeed in the second stage in this type. It is seldom absent (as in the Ophidia), but in all forms that have a projecting snout this bar, rod, or plate forms the axis of such foregrowth of the skull, and may be equally hypertrophied in the Mammals (Cetacea) as in the Elasmobranchs (Pristidæ).

The Crocodilia, as this stage shows, have inherited a *compound* nasal labyrinth—(*a*) the valvular cartilage outside (in front), (*b*) the ethmoidal region, behind, (*c*) the proper nasal roofs, and (*d*) the middle wall formed by the intertrabecula; these are all chondrified continuously, and we must go down to the Amphibians, Elasmobranchs, and Marsipobranchs for a true interpretation of what is seen in these high Reptiles.

In this stage the clefts are fast closing in, and the inner opening of the *persistent pouch*, the first or tympanic cleft, is a mere crescentic slit, and corresponds to what is permanent in some Batrachia.

Instead of the *ichthyic*, large, symmetrical, perforated pharynx there is here a mere funnel-shaped enlargement of the fore end of the œsophagus; and only *three* of the visceral arches are developed at all, whilst only the first attains to its full size.

With the total loss of branchial function there is an extraordinary amount of new specialization; and only by tracing out the early stages can a true interpretation of the parts be made.

In this stage the first and second visceral arches, if compared with those of the Elasmobranchs, Chimæroids, and Urodeles, will be found to be normal, or nearly so.

There are only two main segments on each side in the mandibular arch, viz. the pterygo-quadrate and the articulo-Meckelian. The pier of this foremost arch has a huge "otic process," and a rudimentary "pedicle" with two forks—one a small "ascending process," and the other a small "pterygoid cartilage."

The next arch has several normal branchial segments, like its counterpart, the hyoid of *Chimæra*; but it has also supernumerary segments like those seen in *Acipenser* and in other Ganoids. As in many Selachians, its pharyngo-hyal or upper joint pushes itself into the side of the auditory capsule; below this there is an epihyal and a ceratohyal, the latter stopping short behind the hinge of the mandible, and becoming solid continuously with the articular head of that part, its proper serial homologue. Distally there is but a small *region* of basihyal cartilage continuous with that of the third arch or first branchial, proper. That arch has merely a small pair of cerato-branchials.

Passing on to the *third* and *fourth* stages, we find that the whole of the chondrocranium (with its visceral arches) has become *Sauropsidan*, and the investing bones, which are now demonstrable, are in number and relation quite Crocodilian.

The chondrocranium is better developed than in any existing order of Reptiles and in any kind of Birds; that of the African Ostrich (*Struthio*) comes nearest to it. The best kind for comparison with it, below, is that of the Skate; if compared with that which is above, it is seen to come very near to that of any ordinary Mammal at the same stage, *e.g.* the Pig; but the auditory labyrinth is in the condition in which it is found in an embryo of the Pig three quarters of an inch in length. The occipital condyle, however, in the Crocodile is single, and not double as in the Skate, below, and the Mammal, above; but the development of the occipital arch, the impaction of the large auditory capsules, the continuity of the upper part of the wings of the sphenoid with the nasal and auditory capsules, and the development of the whole basis cranii (crested in the prepituitary region, and carrying the long nasal capsules)—all these things are like what we see in the Mammalia, except that the top of the alisphenoid is not free. The hard palate of this type is equal to what we see in such a mammal as *Myrmecophaga*, where it has its fullest growth, the pterygoids continuing the floor.

As we dissect the arrested and highly modified hyoid arch, we seem to be examining a creature very different from a Mammal; the basal part of the *stapes* is not distinct as in the Frog, and the parts which are specialized to auditory functions are normally Sauropsidan, but have an additional segment, the *suprastapedial*. Yet, below, the basihyobranchial plate and the hinder cornua are very much like what we see even in Man.

But the mandibular arch is as far as can be from that of a Mammal; here it is at its utmost development, the lower jaw of the *oviparous* type in its culmination.

In the Mammal, on the other hand, the arrest of this as well as of the other visceral arches—in all the "Amniota" the *hindermost arches* are suppressed—reveals a great gulf between them and the Sauropsida. This is correlated with the fine and perfect coiling of the *cochlea*; to that highest development of the auditory labyrinth there is superadded, in Mammals, an additional arrested and specialized visceral arch in the outer (tympanic) part of the organ.

In the early stages the mandibular suspensorium of the Crocodile is extremely like that of the more generalized Selachians—*Notidanus*, *Cestracion*—just as the hyoid arch is like that of the Skate, or even of the *Chimæra*.

But the fore part of the pterygo-quadrate bar, or working upper jaw, is arrested in the Crocodile, whilst the "otic process" is inordinately large.

A separate rudiment of the Shark's huge, projecting upper jaw ("pterygoid cartilage") appears, as in *Siredon*, below, and the Passerine birds, above; and so also does a remnant of the great *coronoid crest* of Selachians and Ganoids reappear in the lower jaw of the Crocodile.

Here, in spite of the strong fixation of the quadrate suspensorium, the lower jaw is separated by it from the skull in the squamosal (or temporal) region; whereas in mammals the *overdeveloped* "dentary" bone reaches up to the squamosal, and articulates with it, aborting the simple single *quadrato-Meckelian* rod within.

During the middle period of incubation the hyostapedial chain becomes continuous, and remains for a time united with the articular part of the mandible; and the air-cell in that part, which was first seen in the last stage, burrows still deeper in the mandible at this time. A large annular (spiracular) cartilage is to be seen now, as in the Chelonia and Batrachia.

In the beginning of the latter period of incubation the endoskeletal bony centres are found; the tympanic labyrinth is rapidly developed, and the hyoid arch first becomes severed from the mandible, and then breaks up again into its primary segments.

The specialization of the first pair of clefts in relation to the organ of hearing in the Crocodile is so great and so remarkable, that it is worth while to compare it with what is seen in other types.

In some of the Urodeles (where the stapes is first seen) a second pharyngo-hyal segment is seized by the outgrowing ectosteal plate of the stapes, and is thus united with it to form the columella; in that group there is no cavum tympani.

In the majority of the Anura the first cleft, which in them never opens externally, becomes a considerable tympanic cavity, and opens by a large lateral, internal hole between the pedicle and the stylohyal. The stapes is always distinct, even when, as in *Bombinator*, there is no columella and the merest trace of a tympano-Eustachian pouch; where, as in most cases, the columella is present, it appears long after the stapes, and may be composed of *one*, *two*, or *three* segments; it begins as a styliform second pharyngo-hyal. The epihyal (=stylohyal) end of the suddenly elongated hyoid bar, may, as is the rule, coalesce with the auditory capsule behind the Eustachian opening, or be attached by ligament, or coalesce with the second or permanent pedicle; in all these cases it is below and a little behind the emerging facial nerve. In the Aglossal Anura the Eustachian openings meet at the mid line; in *Dactylethra* and in some of the Phaneroglossa (e. g. *Callula* and *Hylaplesia*) the columella is as large as the average "hyomandibular" of Fishes; in *Pipa* the columella is formed and finished much earlier than in the other types.

In the Ophidia the columella is formed by ossification of a single pharyngohyal; but there is no cavum tympani, and, therefore, no pneumatic bones.

In the lower Lacertilia (e. g. *Hatteria*) and the Chamæleonidæ the cavum tympani is scarcely at all developed, and where it is, as in most of the types, there are no pneumatic bones; yet the columella is very avian, and has, besides its bony shaft and base, upper, external, and descending cartilaginous processes.

In the Chelonia, especially in the lesser freshwater kinds, the squamosal and the quadrate bones are hollowed out to form a large and elegant ear-drum; the opisthotic (mastoid) is also excavated behind the main cavity.

Their columella, with its discoid "extrastapedial," is very much like that of several Anura, especially that of the "Aglossa," and for a time is in two segments; the oval stapedial plate has only a temporary and imperfectly separate existence; here, however, the cartilaginous "annulus tympanum" reappears—a large and highly developed "spiracular cartilage."

But the Crocodiles and Birds have the most remarkable development of the tympanic labyrinth; and in them the two basitemporal wings of the Ichthyopsidan parasphenoid reappear as primarily distinct parostoses; these bones are intimately connected with the auditory apparatus.

In the Crocodiles as well as in the Aves Ratitæ these basitemporals are lateral, outside the basisphenoid; but in the Aves Carinatæ they are much larger, and meet and coalesce below the skull-base.

In the Bird the columella is a pharyngo-hyal, with a dilated upper part; it coalesces with an epihyal (=stylohyal) rudiment of the main bar, through the medium of an "infrastapedial" (=interhyal) tract, which is later in appearance than the other parts. The distal part of the hyoid arch is a hypohyal, which meets its fellow at a sharp angle in the tongue to form a "glossohyal"

Here we miss what is found in the Crocodile, namely, a distinct suprastapedial; the distal rudiment of the main bar does run into the *ceratohyal region* for a small extent.

In the Birds the Eustachian tubes open at the mid line in one common *vestibule*, which is the homologue of the middle Eustachian passage of the Crocodile. Also in Birds the periosteal growths of the basisphenoid (which start from the little cartilaginous lingulæ, parts present in both Crocodiles and Birds) there form, above the basitemporal floor, a pair of "anterior tympanic recesses." These trumpet-shaped cavities answer, in some degree, to the passages in the Crocodile where the lateral and median Eustachian tubes combine; they converge towards each other, but do not meet, in the thick diploë of that part of the skull.

In the Crocodile the quadrate forms much of the tympanic cavity; in the Bird it is pneumatic, and opens by a hole into that cavity, which is enlarged by a wing of the exoccipital. That cavity also, as in Crocodiles, communicates with cavities in the occipito-otic bones above. In the Crocodile the whole hind skull is excavated by these pneumatic diverticula; in Birds the whole hind (as well as fore) skull is pneumatic, but the cavities are traversed by fine reticulations of the diploë.

In the Crocodile, as pointed out by Professor Huxley, the tympanic cavity *in the quadrate* communicates with a hollow in the "articulare" by the "siphonium." In the Birds, as shown by Professor Nitzsch, the "siphonium" arises *behind* the quadrate in the general tympanic space.

In the Crocodiles I have seen no bony centres round the "siphonium;" but in the Birds these fragments of the "os tympanicum" (proper) sometimes number as many as six or seven, and the main bone forms a ring to the pneumatic tube; two such centres are seen inside the "cartilaginous annulus" in *Dactylethra*, an aglossal Anuran.

I need not show the reader how all these modifications tend towards, or illustrate, what we are familiar with in the auditory apparatus of Man, and the Mammalia, generally. But there are some things worth especial notice.

In the Insectivora (*e. g.* Mole and Hedgehog) the basisphenoid gives off wings to enlarge the tympanic cavities; in the Marsupials the alisphenoids do the same; whilst in others (notably many of the Carnivora) a distinct, hollow *lunule* of cartilage appears on the outside of the parachordals: it is the innermost segment of the external ear, and helps the more superficial "os tympanicum" to form the drum-cavity[1]. Pneumaticity of the hind skull is very variable in Mammals; it is very much developed in *Petaurus sciureus*. In some Mammals large air-cavities are developed, retrally, in the base of the skull, from the hind part of their extensive nasal labyrinth; these burrow the skull-base in the same way as the Eustachian tubes do in the Crocodile.

In the Mammals the first and second visceral arches are formed after the *hyostylic* pattern of the Skate, but are much specialized. Both the *malleus* and the *incus* lie under the tegmen tympani. The part answering to the cerato-branchial (Meckel's cartilage) is still large in *Manis*, at birth, and in that stage it rapidly re-enlarges from the sharp end of the "processus gracilis," and lies inside the hind part of the dentary. The stapes is not a *periotic* element; the incus is either a second "pharyngo-hyal" added to the stapes, *or the quadrate in an arrested state*; the "epihyal" end of the main bar is ossified as the "tympano-hyal" (*Flower*); the rest of that bar is the "ceratohyal," which finishes below as a "hypohyal" to articulate with the common "basihyo-branchial." The little "interhyal" (= infrastapedial of the Sauropsida) is detached and carried away by the perfectly specialized *stapedius muscle*, to whose tendon it becomes attached, and thus gets to be united to, and often ankylosed with, the neck of the stapes[2].

I put these things down as they appear to me from my present standpoint; anyhow the study of the development of the Crocodile's skull is very profitable, and from it I hope to borrow much light in a renewed investigation of the Mammalian skull in its various ordinal modifications. If the Crocodile does not lie directly below the Mammals, it nevertheless shows us how the Mammals may have arisen from some generalized oviparous form.

[1] There is a division between the two parts of the "cavum tympani" in the Carnivora: the bony and cartilaginous *annuli* are not distinct in most Mammals, but the bone-cells soon transform the cartilaginous *lunule* into a bony ring; outside this, the inner part of the *concha* is more or less segmented.

[2] That little segment, with the stapes itself, would appear to be all that the Mammal shows of the stapedial chain of the oviparous types; Professor Huxley's terms for the parts of that chain (namely, *stapedial*, *medio-stapedial*, &c.) are of permanent value, being morphologically accurate.

DESCRIPTION OF THE PLATES.

PLATE LXII.

Fig. 1. *Alligator mississipensis*, Daudin (1st Stage): total length 11 lines (head 3, body 5, tail 3). Side view of embryo, × 6 diameters.

Fig. 2. The same, lower view of head, × 6 diam.

Fig. 3. *Alligator mississipensis* (2nd Stage): total length $1\frac{1}{2}$ inch (head 4 lines, body 6, tail 8). Side view of embryo, × 6 diam.

Fig. 4. The same, lower view of head, × 6 diam.

Fig. 5. *Crocodilus palustris*, Lesson (3rd Stage): total length 2 inches (head 6 lines, body 8, tail 10). Side view of embryo, × $3\frac{1}{5}$ diam.

Fig. 6. The same, upper view of head, × $3\frac{1}{5}$ diam.

Fig. 7. The same, lower view of head, × $3\frac{1}{5}$ diam.

Fig. 8. *Crocodilus palustris* (3rd Stage): total length $2\frac{1}{4}$ inches (head 5 lines, body 10, tail 12). Side view of embryo, × $2\frac{4}{5}$ diam.

Fig. 9. The same, upper view of head, × $2\frac{4}{5}$ diam.

Fig. 10. *Crocodilus palustris* (4th Stage): total length $3\frac{1}{2}$ inches (head 11 lines, body 13, tail 18). Upper view of head of embryo, × 2 diam.

Fig. 11. The same, side view of head, × 2 diam.

Fig. 12. *Alligator mississipensis* (5th Stage): total length $4\frac{1}{4}$ inches (head 1 inch), × 2 diam.

Fig. 13. The same, front view of head, × 2 diam.

Fig. 14. The same, upper view of head, × 2 diam.

PLATE LXIII.

Fig. 1. *Alligator mississipensis* (1st Stage). Head of embryo, with lower arches removed; lower view, × $12\frac{1}{2}$ diam.

Fig. 2. The same, with lower surface of base of skull exposed, × $12\frac{1}{2}$ diam.

Fig. 3. *Alligator mississipensis* (2nd Stage). Head of embryo, with lower arches removed, × 10 diam.

Fig. 4. The same, with lower surface of base of skull exposed, × 10 diam.

Fig. 5. The same, base of skull, oblique view, × 15 diam.

Fig. 6. The same, dissected head of embryo, upper view, × 10 diam.

Fig. 7. The same, head of embryo, in vertical section, × 10 diam.

Fig. 8. The same object, with brain removed, × 10 diam.

PLATE LXIV.

Fig. 1. *Alligator mississipensis* (2nd Stage). Subhorizontal section of head (No. I), lowest, × 10 diam.

Fig. 2. The same (No. II), × 10 diam.

Fig. 3. The same (No. III), × 10 diam.

Fig. 4. The same (No. IV), highest, × 10 diam.

Fig. 5. *Crocodilus palustris* (3rd Stage): embryo, 2 inches long. Base of skull, upper view, × $6\frac{2}{3}$ diam.

Fig. 6. Part of same object, × 20 diam.

Fig. 7. *Crocodilus palustris* (3rd Stage): $2\frac{1}{3}$ inches long. Palatal view of head, × $4\frac{2}{3}$ diam.

Fig. 8. The same object, dissected, × $4\frac{2}{3}$ diam.

Fig. 9. The same, upper view of head, dissected, × $4\frac{2}{3}$ diam.

Fig. 10. The same, inner view of mandible, × $4\frac{2}{3}$ diam.

Fig. 11. The same object, outer view, × $4\frac{2}{3}$ diam.

PLATE LXV.

Fig. 1. *Crocodilus palustris* (4th Stage): embryo, $3\frac{1}{2}$ inches long. Chondrocranium of embryo, upper view, × $5\frac{1}{3}$ diam.

Fig. 2. The same object, lower view, × $5\frac{1}{3}$ diam.

Fig. 3. Part of same object, outspread, lower view, × 8 diam.

Fig. 4. Same embryo, visceral arches, obliquely external view, × $5\frac{1}{3}$ diam.

Fig. 5. *Alligator mississipensis* (5th Stage): larger embryos of this species, $4\frac{1}{4}$ inches long. Palatal view of head, with lower arches removed, × 3 diam.

Fig. 6. The same, head in vertical section, × $4\frac{1}{2}$ diam.

Fig. 7. The same object, with the brain removed, × $4\frac{1}{2}$ diam.

Fig. 8. The same head, outer view of chondrocranium, × $4\frac{1}{2}$ diam.

Fig. 9. The same head, upper view of hyobranchial plate, × $4\frac{1}{2}$ diam.

PLATE LXVI.

Fig. 1. *Alligator mississipensis* (5th Stage): largest embryos. Dissected skull, side view, × $4\frac{1}{2}$ diam.

Fig. 2. The same, inner view of mandible, × $4\frac{1}{2}$ diam.

Fig. 3. The same, lower view of skull, × $4\frac{1}{2}$ diam.

Fig. 4. The same, upper view of skull, × $4\frac{1}{2}$ diam.

Fig. 5. The same, transversely vertical section (1st) of head through external nostrils, × 8 diam.

Fig. 6. The same (2nd section), behind external nostrils, × 8 diam.
Fig. 7. The same (3rd section), through middle of nasal capsule, × 8 diam.
Fig. 8. The same (4th section), through turbinal folds, × 8 diam.
Fig. 9. The same (5th section), through rhinencephalic recess, × 8 diam.
Fig. 10. The same (6th section), through antorbital wall, × 8 diam.

PLATE LXVII.

Fig. 1. *Alligator mississipensis* (as in last Plate, 7th section). Through fore part of eyeball, × 8 diam.
Fig. 2. The same (8th section), through orbito-sphenoids, × 8 diam.
Fig. 3. The same (9th section), through middle part of eyeballs, × 8 diam.
Fig. 4. The same (10th section), through hind part of eyeballs, × 8 diam.
Fig. 5. The same (11th section, part), through prepituitary region, × 8 diam.
Fig. 6. The same (12th section, part), through pituitary region, × 8 diam.
Fig. 7. The same (13th section), through alisphenoid, × 8 diam.
Fig. 8. The same (14th section), through auditory capsules, × 8 diam.

PLATE LXVIII.

Fig. 1. *Alligator mississipensis* (2nd Stage). Additional (*partial*) view of subhorizontal section of the head (as in Pl. LXIV. figs. 1–4), No. V, through first cleft and first and second arches, × 18 diam.
Fig. 2. The same (No. VI), a similar section, × 18 diam.
Fig. 3. The same (No. VII), through notochord and pituitary body, × 18 diam.
Fig. 4. The same (No. VIII), through quadrate and hyoid, × 18 diam.
Fig. 5. The same (No. IX), through hinge of mandible, × 18 diam.
Fig. 6. The same (No. X), a similar section, higher up, × 18 diam.
Fig. 7. The same (No. XI), through Meckel's cartilage and hyoid, × 18 diam.
Fig. 8. The same (No. XII), through the same parts, higher up, × 18 diam.
Fig. 9. The same embryo. Outer view of quadrate, part of mandible, and hyoid arch, × 16 diam.
Fig. 10. *Crocodilus palustris* (3rd Stage): $1\frac{5}{8}$ inch long. The same arches, × 12 diam.
Fig. 11. Part of same object, × 24 diam.
Fig. 12. The same species (4th Stage); embryo, $3\frac{1}{2}$ inches long. The same arches, outer view, × $7\frac{1}{4}$ diam.
Fig. 13. The same object, inner view, × $7\frac{1}{4}$.
Fig. 14. Part of same object, inner view, × $14\frac{1}{2}$ diam.
Fig. 15. *Alligator mississipensis* (5th Stage): embryo, $4\frac{1}{2}$ inches long. Hyoid arch, inner view, × 12 diam.
Fig. 16. Part of hyoid arch of another specimen of same, × 12 diam.

PLATE LXIX.

Fig. 1. *Crocodilus palustris* (5th Stage): embryo, $4\frac{1}{2}$ inches long. Hyoid arch, outer view, × 12 diam.

Fig. 2. Same species (5th Stage): embryo, 5 inches long. Hyoid arch, outer view, × 12 diam.

Fig. 3. The same object (part), basal view of columella, × 12 diam.

Fig. 4. Same species (7th Stage): ripe embryo, 10 inches long. Outer view of hyoid arch, × 12 diam.

Fig. 5. Same species (6th Stage): embryo, $5\frac{3}{4}$ inches long. Hind part of skull, outer view, × $3\frac{3}{4}$ diam.

Fig. 6. Same skull, inner view of vertical section, × $3\frac{3}{4}$ diam.

Fig. 7. Same species (7th Stage): embryo, $9\frac{1}{2}$ inches long. Inner view of vertical section of skull, × 3 diam.

Fig. 8. Part of same, inner view, × 6 diam.

Fig. 9. Same species (7th Stage): ripe embryo, 10 inches long. Side view of skull, × $2\frac{2}{3}$ diam.

Fig. 10. Same skull, inner view of mandible, × $2\frac{2}{3}$ diam.

Fig. 11. Same skull, end view, × $2\frac{2}{3}$ diam.

PLATE LXX.

Fig. 1. *Crocodilus palustris* (7th Stage): ripe young, 10 inches long. Lower view of skull, × $2\frac{2}{3}$ diam.

Fig. 2. Same skull, upper view, × $2\frac{2}{3}$ diam.

Fig. 3. *Crocodilus* ——?, sp. (7th Stage): ripe young. Part of base of skull, lower view, × $3\frac{1}{3}$ diam.

Fig. 4. Part of same object, upper view, × $3\frac{1}{3}$ diam.

Fig. 5. Part of same object, lower view, × $3\frac{1}{3}$ diam.

Fig. 6. Supraoccipital of same skull, upper view, × $3\frac{1}{3}$ diam.

Fig. 7. *Crocodilus palustris* (7th Stage): ripe embryo, 10 inches long. Auditory region, outer view, × $5\frac{1}{3}$ diam.

Fig. 8. Same species (6th Stage), part of palate of embryo, 6 inches long, × $3\frac{1}{3}$ diam.

Fig. 9. Same species (7th Stage): ripe young, 10 inches long. Inside of nasal labyrinth, side view, × $2\frac{2}{3}$ diam.

Fig. 10. Same species (7th Stage): ripe young, 10 inches long. Hyobranchial plate, upper view, × $2\frac{2}{3}$ diam.

Fig. 11. Right prootic of *Crocodilus* ——?, sp., outer view, × 5 diam.

Fig. 12. *Crocodilus palustris* (7th Stage): ripe young, 10 inches long. First section of head, transversely vertical, × 5 diam.

Fig. 13. Same head, 2nd section, × 5 diam.

PLATE LXXI.

Fig. 1. Same head *of Crocodilus palustris* as in figs. 12 & 13 of Plate LXX., 3rd section, × 5 diam.
Fig. 2. The same, 4th section, × 5 diam.
Fig. 3. The same, 5th section, × 5 diam.
Fig. 4. The same, 6th section, × 5 diam.
Fig. 5. The same, 7th section, × 5 diam.
Fig. 6. The same, 8th section, × 5 diam.
Fig. 7. The same, 9th section, × 5 diam.

EXPLANATION OF ABBREVIATIONS.

The Roman numerals refer to nerves or their foramina.

ag. Angulare.
al.s. Alisphenoid.
al.f. Alisphenoidal fenestra.
a.p. Ascending process.
ar. Articulare.
ar.c. Articular cartilage.
ar.p.c. Articular pneumatic cavity.
a.s.c. Anterior semicircular canal.
au. Auditory capsule.
a. ty. Annulus tympanicus.
b.mn. Basimandibular.
b.o. Basioccipital.
b.s. Basisphenoid.
b.t. Basitemporal.
C^{1}. Fore brain.
C^{1a}. Hemispheres.
C^{1b}. Olfactory lobes.
C^{2}. Mid brain.
C^{3}. Hind brain.
c.br. Ceratobranchial.
chl. Cochlea.
c.hy. Ceratohyal.
cl. Cleft.
cr. Coronoid.
cr.c. Coronoid cartilage.
e. Eye.
e.hy. Epihyal.
e.n. External nostril.
e.o. Exoccipital.
ep. Epiotic.
e.st. Extrastapedial.
f. Frontal.
fo. Fontanelle.
f.r. Fenestra rotunda.
fs.o. Fenestra ovalis.
h.br. Hyobranchial.
h.s.c. Horizontal semicircular canal.
i.c. Internal carotid.
i.hy. Interhyal.
i.n. Inner nares.
inf. Infundibulum.
i.st. Infrastapedial.
i.tb. Inferior turbinal.
i.tr. Intertrabecula.
j. Jugal.
l. Lacrymal.
l.i. Lacrymal involution.
l.eu. Lateral Eustachian tube.
l.o.al. Lateral orbito-alisphenoidal fenestra.
m. Mouth.
m.eu. Middle Eustachian tube.
mk. Meckel's cartilage.
mn.f. Mandibular fenestra.

mx. Maxillary.
my. Myelon.
n. Nasal bone.
na. Nasal roof.
nc. Notochord.
n.f. Nasal floor.
n.w. Nasal wall.
o.al.f. Orbito-alisphenoid fenestra.
oc.c. Occipital condyle.
ol. Olfactory capsule.
op. Opisthotic.
o.s. Orbito-sphenoid.
ot.p. Otic process.
p. Parietal.
pa. Palatine.
p.cl. Posterior clinoid.
pf. Prefrontal.
pg. Pterygoid.
pg.c. Pterygoid cartilage.
pl. Pineal gland.
p.n. Prenasal cartilage and Posterior nares.
p.ob. Postorbital.
p.p. Pars plana.
p.s. Presphenoid.
p.s.c. Posterior semicircular canal.
px. Premaxillary.
py. Pituitary body or space.
q. Quadrate.
q.c. Quadrate condyle.
q.j. Quadrato-jugal.
s.ag. Supraangulare.
s.n. Septum nasi.
sp. Splenial.
sph. Siphonium.
s.st. Suprastapedial.
s.st'. Stem of suprastapedial.
st. Stapes.
tg. Tongue.
tr. Trabecula.
tr.p. Transpalatine.
u.o.al. Upper orbito-sphenoidal band.
u.tb. Upper turbinal.
v. Vomer.